First Encounter With Capital Budgeting Rules

In this chapter, we maintain the assumptions of the previous chapter:

- We assume perfect markets, so we assume four market features:
  1. No differences in opinion.
  2. No taxes.
  3. No transaction costs.
  4. No big sellers/buyers—we have infinitely many clones that can buy or sell.
- We assume perfect certainty, so we know what the rates of return on every project are.
- For the most part, we assume equal rates of returns in each period (year).

- A capital budgeting rule is a method to decide which projects to take and which to reject. (The name "capital budgeting" is a relic.)
- $NPV > 0$ is the best rule.
- Other rules can make some good sense.
- Some rules that are in common use—especially the payback rule—make much less sense. You must understand why.

Why is NPV the Right Rule?

This was covered in #2, where you saw NPV for the first time.

Q1: How abundant are positive NPV projects in a perfect world?

- In perfect markets under certainty, a positive NPV project is equivalent to an "arbitrage:" money for nothing.

  (Money for nothing, chicks for free [Dire Straits].)

- Any alternative rule must simplify back to NPV when financial markets become more and more perfect and uncertainty becomes less and less.

  It must be a generalization of NPV.

Separability of Investment and Consumption

Q2: You have $100 in cash. The prevailing interest rate is 20% per annum. You have two investment choices:

- A project that costs $100 and will return $150 next year.
- Ice Cream—and you love ice cream.

Problem: You know you will be dead next year. What should you do? (Should you forego the ice cream for the greater social good and die unhappily?)

Q3: Does project value depend on when you need cash?

(This is called separation (or separability) of investment and consumption decisions. Actually, in a perfect market, this is really separation between investment decisions and personal identity.)

Robustness: How Good are Approximations?

Assume that we believe that the expected cash flow is $500 and the expected rate of return (cost of capital) is 20%. This is a 1-year project.

Q4: Is it worse to commit an error in cash flows or in cost of capital?

Q5: Does your conclusion change if this is a 50-year project?

The Internal Rate of Return

Q6: What is the holding rate of return on a project that costs $13.16 million, and pays $7 million next year, followed by $8 million the year after?

Time	0	1	2
Cash Flow	–$13.16	+$7	+$8

The Internal Rate of Return

To answer the previous question, you need a measure that generalizes the rate of return to more than one inflow and one outflow. The most prominent such measure is the internal rate of return.

IMPORTANT: The IRR (internal rate of return) of a project is defined as the rate-of-return-like-number which sets the NPV equal to zero.

$$0 = C_0 + \frac{\mathcal{E}(\tilde{C}_1)}{1+IRR} + \frac{\mathcal{E}(\tilde{C}_2)}{(1+IRR)^2} + \frac{\mathcal{E}(\tilde{C}_3)}{(1+IRR)^3} + \ldots$$

In the context of bonds, the IRR is also called the Yield-To-Maturity (YTM).

Example: $C_0 = -\$13.16$, $C_1 = +\$7$, $C_2 = +\$8$. Solve

$$-\$13.16 + \frac{\$7}{1+IRR} + \frac{\$8}{(1+IRR)^2} = 0$$

$$\Longleftrightarrow \quad IRR \approx 9\%$$

Q7: Check this!

IRR is in common use. You must understand it inside-out.

The Concept of IRR

- The IRR is *not* a rate of return in the sense that we defined a rate of return in the first class as a holding return, obtained from investing C_0 and later receiving C_t.
- IRR is a "characteristic" of a project's cash flows. It is purely a mapping from—i.e., a summary statistic of—many cash flows into one single number, just like the average cash flow or standard deviation of cash flow or auto-correlation of cash flows are.
- Intuitively, you can consider an "internal rate of return" to be sort of a "time-weighted average rate of return intrinsic to cash flows"—similar to a rate of return.

  Sorry, this is the best intuition that I have to offer.
- Intuitively, a project with a higher IRR is more "profitable."
- (Later, we will compare project IRR's to costs of capital.)

Perhaps insert book figure here.

- Multiplying each and every cash flow by the same factor, positive or negative, will not change the IRR. (Look at the formula.)

Finding the IRR

- There is no general algebraic closed-form formula that solve the IRR for many cash flows.

  The solution is the answer to a polynomial. With two many cash flows, its order is too high.

- Manual Iteration = intelligent trial-and-error.

  Do an example:

- Computer-preprogrammed (builtin) iteration—Excel, Openoffice, Financial Calculators.

  On the exams, I will not ask you a difficult question to find an IRR. Thus, a financial calculator will not be of much help.

  In Excel, this function is called IRR. You can find an example of how to use it in the book.

More IRR Problems

- Presume: $C_0 = \$40$, $\mathcal{E}(\tilde{C}_1) = -\$80$, and $\mathcal{E}(\tilde{C}_2) = 104$.

  Q8: What is the IRR?

- Presume:
  $C_0 = -\$100$, $\mathcal{E}(\tilde{C}_1) = +\$360$, $\mathcal{E}(\tilde{C}_2) = -\$431$, $\mathcal{E}(\tilde{C}_3) = +\$171.60$.

  Q9: Is 10% the IRR?

  Q10: Is 20% the IRR?

  Q11: Is 30% the IRR?

  Q12: Which one is it? Which one will Excel give?

For nerds: these cutoffs define regions of IRR where you would or would not take the project. Don't bother.

Obscure?

Important: You are guaranteed one unique IRR if you have a first, up-front cash flow that is an investment (a single negative number), followed only by positive cash flows (payback).

- This cash flow pattern is the case for financial bonds.
  Thus, the YTM for a bond is usually unique.
- This cash flow pattern is also usually the case for most normal corporate investment projects.
- In the real world, most projects do not have both positive and negative cash flows that alternate many times. (There are some projects that require big overhauls/maintenance, so it can happen.)

But be aware of these issues.

PS: You will soon learn the difference between promised and expected returns. An IRR based on promised cash flows is a promised IRR. It should never be used for capital budgeting purposes. (You need to use expected cash flows under uncertainty.)

IRR as a Capital Budgeting Rule

- Because you cannot do any better than doing right, always using NPV is best.
- The nice thing for investment projects is that the rule

Important:

Invest if "IRR project" $>$ "cost of capital (IRR elsewhere)",

where the cost of capital is your prevailing interest rate $\mathcal{E}(\tilde{r})$, often (but not always) leads to the same answer as the NPV rule, *and thus the correct answer*. This is also the reason why IRR has survived as a common method for "capital budgeting."

- This applies to "projects" that are "first money out, then money in."
- If you use IRR *correctly* and in the right circumstances, it can not only give you the right answer, it can also often give you nice extra intuition.
- Advantage: It delays learning the cost of capital.

- Watch out for the sign:

Important: Borrow if "IRR of capital" $<$ "IRR elsewhere"

This applies to "projects" that are "first money in, then money out."

- In case of sign doubts, calculate the NPV!

More IRR Problems

IRR usually has one unique solution *if* there is one negative cash flow upfront and only positive or zero cash flows in the future; or vice-versa. This is standard in YTM applications.

- Recall Uniqueness of IRR Issues. This applies here, too.
- Exclusive Projects—Which one?
  Project A: $C_0 = -\$80$, $\mathcal{E}(\tilde{C}_1) = +\$50$, and $\mathcal{E}(\tilde{C}_2) = +\$100$.
  Project B: $C_0 = -\$85$, $\mathcal{E}(\tilde{C}_1) = +\$100$, and $\mathcal{E}(\tilde{C}_2) = +\$45$.

Q13: What are the two project IRRs?

47% and 52%. CHECK!

Q14: Which project is better?

- Which $\mathcal{E}(\tilde{r})$ to compare to?

Q15: For the project on page 5 ($-13.16, +\$7, +\$8 \Rightarrow IRR \approx 9\%$), if the expected rate of return (cost of capital) is 8% for 1 year and 10% (annualized) for 2 years, should you or should you not take the project?

IRR

Disadvantages:

1. IRR is scale insensitive (which causes problems comparing projects.)
2. There may be no IRR.
3. There may be multiple IRRs.
4. The benchmark cost of capital may be time-varying, in which case the IRR capital budgeting rule fails.

Advantages:

- Your cost of capital (the prevailing $\mathcal{E}(\tilde{r})$) does not enter into the IRR calculation.
- IRR has the advantage that you do not need to recalculate the whole project value under different cost-of-capital scenarios (if you want to play around with projects before talking to the bank).

The Profitability Index

Time	0	1	2
Cash Flow	–$13.16	+$7	+$8

- Used occasionally. Not as common as IRR.
- The profitability index is the PV of future cash flows, divided by the cost (made positive). Here, if $r = 20\%$, then

$$\text{PI} = \frac{\text{PV}(\$7,\$8;20\%)}{-(-\$13.16)} = \frac{\$11.39}{\$13.16} \approx 0.8655$$

  If $r = 5\%$, then

$$\text{PI} = \frac{\text{PV}(\$7,\$8;5\%)}{-(-\$13.16)} = \frac{\$13.92}{\$13.16} \approx 1.058$$

- Capital Budgeting Rule:

  Invest if PI > 1. Reject if PI < 1.

  Often gives the same recommendation as NPV.
- Shares all the same problems as IRR.
  (Most importantly, it lacks the concept of project scale, which is a problem for "either-or" projects [higher PI projects are not necessarily better than lower PI projects].)
- Does not have the main advantage of IRR (which is that the cost of capital is kept separate).

Other Investment Rules

- The most common alternative rule is the so-called "payback rule." It measures how long it takes to get your money back.
- Capital budgeting rule version:

  Take projects with shortest payback time.

- Which project is better?

	Time	0	1	2	Payback
A	Cash Flow	-$1	+$2		
B	Cash Flow	-$1		+$200	

- It may be useful if managers cannot be trusted to provide good estimates of far out future cash flows. It's harder to lie if you have to claim that you can prove project profitability within 1 year.

  All these other rules, if used for project accept/reject, are pretty dumb *if* you plan to use them "for real." They can provide some useful background decision information, which helps for background information, for informal conversation, or if capital is highly constrained. (Even in this case, a form of NPV with a higher discount rate may be better, though.) When the point is stark enough, they may make the point that the NPV is very high in an intuitive and forceful manner.

Q16: Successful discoteques have a payback period of half a year. What does this tell you about their NPV?

Important: For the most part, you should avoid non-NPV rules.

Real Life Capital Budgeting Rules

Method	CFO Usage	Yields Correct Answer
Internal Rate of Return (IRR)	(76%)	Often
Net Present Value (NPV)	(75%)	Always
Payback Period	(57%)	Rarely
Earning Multiples (P/E Ratios)	(39%)	With Caution
Discounted Payback	(30%)	Rarely
Accounting Rate of Return	(20%)	Rarely
Profitability Index	(12%)	Often

Rarely means "usually no—often used incorrectly in the real world." NPV works *if correctly applied*, which is why I added the qualifier "almost" to always. Of course, if you are considering an extremely good or an extremely bad project, almost any evaluation criterion is likely to give you the same recommendation. (Even a stopped clock gives you the right answer twice a day.)

Source: Campbell and Harvey, 2001.

Homework Assignment

1. Reread Chapter 4.
2. Read Chapter 5.
3. Hand in all Chapter 4 end-of-chapter problems, due in 7 days.

Additional homework: Check out the interest rate for a 6-month and a 5-year certificate of deposit (CD) at your local bank.