Capital Budgeting Rules

(Welch, Chapter 04)

Ivo Welch

UCLA Anderson School, Corporate Finance, Winter 2017

December 15, 2016

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

Maintained Assumptions

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—infinitely many clones that can buy or sell.
- We again 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).

Definition of Capital Budgeting Rule

- A **capital budgeting** rule is a method to decide which projects to take and which to reject.

  (The name “capital budgeting” is an anachronistic relic.)
- Accept project iff NPV > 0 is the correct rule in a perfect market.
- Other rules can help your intuition at times, but they can only be either redundant or wrong.
- Some rules that are in common use—such as the payback rule—can be badly wrong and make less sense. **You must understand why.**

Why is NPV the best rule?

- This was covered in the previous chapter.
- The reason is simple: If there were a better rule that would come up with a different answer in the simplest scenario (perfect markets, no uncertainty), it would leave good projects (money) on the table. This would be a mistake. You could "arbitrage" it.
- Ergo, any alternative rule must converge to the NPV rule as the financial market gets closer to perfection—or this alternative rule is simply wrong.

How common and easy to find should positive-NPV projects be in a perfect world?

- In perfect markets under certainty, positive NPV projects are close to "arbitrage:" it is money for nothing. (This extends to negative NPV projects if someone is willing to buy it from you.)
- Ergo, positive NPV projects should be hard to locate, unless you have some resources that are not widely available to everyone.
- What should happen in the real world if positive NPV projects were abundant is that the prevailing interest rate should adjust.

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

- Project costs \$100 and will return \$150 next year.
- Ice Cream—and you love ice cream.

The problem is you know that you will be dead next year. What should you do? (Should you forego the ice cream for the greater social good and die unhappily?)

Does project value depend on when you need cash?

In our perfect world, can you make your decision on investment and consumption choices separately, or do you need to make both of them at the same time (jointly)?

In a perfect market, how does project value depend on who you are (the identity of the owner)?

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

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

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.

- 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.

$$0 = C_0 + \frac{E(C_1)}{(1+\text{IRR})} + \frac{E(C_2)}{(1+\text{IRR})^2} + \frac{E(C_3)}{(1+\text{IRR})^3} + \ldots$$

  In the context of bonds, IRR is called Yield-To-Maturity (YTM).
- Example: $C_0 = -\$13.16$, $C_1 = +\$7$, $C_2 = +\$8$. Solve

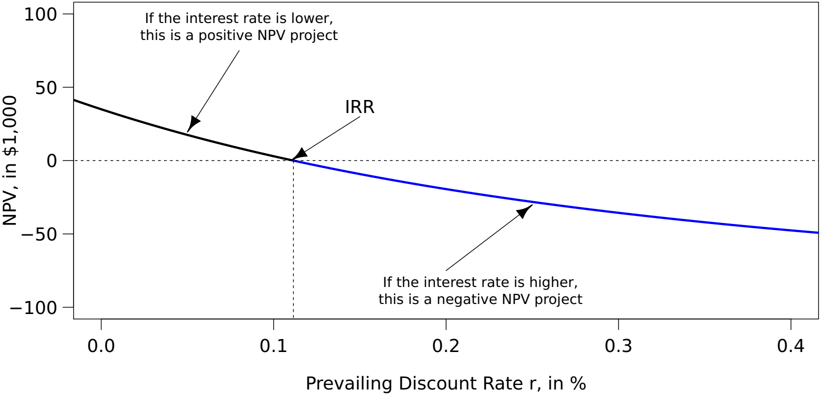
$$-\$13.16 + \frac{\$7}{(1+\text{IRR})} + \frac{\$8}{(1+\text{IRR})^2} = 0 \quad \iff \quad \text{IRR} \approx 9\%$$

  If there are only one inflow and one outflow, then the IRR **is** the rate of return. IRR is a generalization of the rate of return.
- IRR is in common use. You must understand it inside-out.

Is 9% really the correct IRR for $C_0 = –\$13.16$, $C_1 = +\$7$, $C_2 = +\$8$?

IRR and NPV

Project Flows: –\$100, \$5, \$10, \$120.



At IRR=12%, this is a 0-NPV project.

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 rate of return, obtained from investing C_0 and later receiving C_t.
- If there are only two cash flows, IRR simplifies into the rate of return.
- 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."
- Multiplying each and every cash flow by the same factor, positive or negative, will not change the IRR. (Look at the formula.)

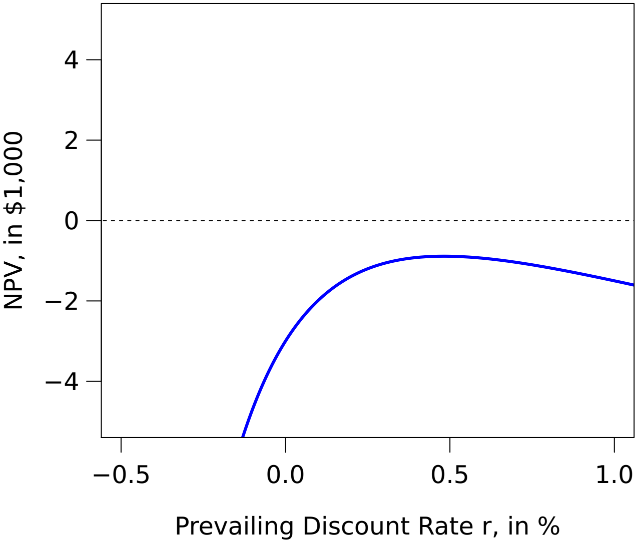
Finding the IRR

- There is no general algebraic closed-form formula that solves the IRR for many cash flows.
  - The IRR solution is the zero-point of a higher-order polynomial. With three or more cash flows, this is a mess or impossible.
- Manual iteration = intelligent trial-and-error.
- Many spreadsheets and calculator have trial-and-error methods built-in.
  - On the exams, you will not be asked to find a complex IRR. Thus, a financial calculator will not be of much help.
  - For example, in Excel, this function is called IRR(). You can find an example of how to use it in the book.

If $C_0 = \$40$, $C_1 = -\$80$, $C_2 = \$104$, what is the IRR?

No IRR

The project is positive or negative NPV for any interest rate.



If $C_0 = –\$100$, $C_1 = +\$360$, $C_2 = –\$431$, $C_3 = +\$171.60$, is 10% the IRR?

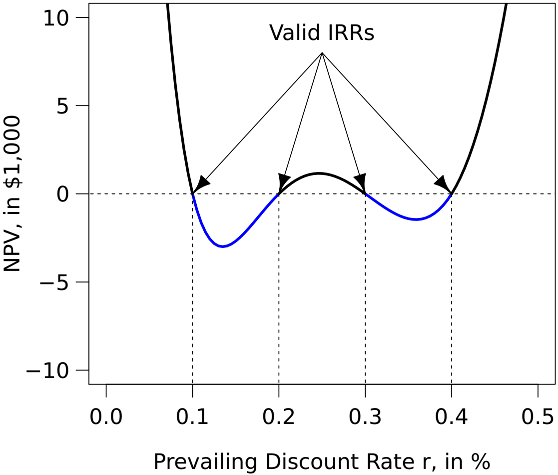
If $C_0 = -\$100$, $C_1 = +\$360$, $C_2 = -\$431$, $C_3 = +\$171.60$, is 20% the IRR?

If $C_0 = -\$100$, $C_1 = +\$360$, $C_2 = -\$431$, $C_3 = +\$171.60$, is 30% the IRR?

Which is the correct IRR for this project? Which answer will Excel give?

An Example of Multiple IRRs

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



Are these irrelevant and absurd IRR problems?

A little but not greatly. You are guaranteed one unique IRR if you have at first only up-front cash flows that are investments (negative numbers), followed only by payback (positive cash flows) after the investment stage.

- This cash flow pattern is the usual case for financial bonds. Thus, the YTM for bonds 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. (But there are projects that require big overhauls/maintenance, where it can happen.)

You must be aware of these issues, lest they bite you one day unexpectedly.

- 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. (For useful IRR [capital budgeting] calculations, you will need to use the expected cash flows in the numerator, not the promised ones—just as you need to do in the NPV context.)

IRR as a Capital Budgeting Rule

- The IRR capital budgeting rule is
  - if the project begins with only money out, followed by only money in

$$\text{Invest If:} \qquad \text{Project IRR} > \text{cost of capital (r)}$$

  - if the loan begins with only money in, followed by only money out

$$\text{Borrow If:} \qquad \text{Project IRR} < \text{cost of capital (r)}$$

  - In case of sign doubts, calculate the NPV!
- The IRR rule leads often (but not always) to the same answer as the NPV rule, *and thus to the correct answer*. This is also the reason why IRR has survived as a common method for "capital budgeting." Because you cannot improve on "correct," the NPV capital budgeting rule is at least as good as the IRR capital budgeting rule.
- 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 about your project itself, separate from the capital markets.
- IRR's Advantage: It allows computations *before* you find out your cost of capital.
- IRR uniqueness and multiplicity problems can apply in this context, too.

The prevailing cost of capital is 20%. Now consider two exclusive projects—which one should you take?

- A: $C_0 = -\$80$, $C_1 = +\$50$, $C_2 = +\$100$.
- B: $C_0 = -\$85$, $C_1 = +\$100$, $C_2 = +\$45$.

Are 42%, 47%, 52%, or 57% the project IRRs of A and B?

If you can take only one of the two projects, which is better?

For the project with which we started ($C_0 = -13.16$, $C_1 = +\$7$, $C_2 = +\$8 \Rightarrow \text{IRR} \approx 9\%$), if the cost of capital is 8% for 1 year and 10% (annualized) for 2 years, should you or should you not take the project?

IRR vs NPV Capital Budgeting Rules

- 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 r) does not enter into the IRR calculation.
  - 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 investors).

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
$$\mathrm{PI} = \frac{\mathrm{PV}(\$7, \$8; 20\%)}{-(-\$13.16)} = \frac{\$11.39}{\$13.16} \approx 0.8655$$
If $r = 5\%$, then
$$\mathrm{PI} = \frac{\mathrm{PV}(\$7, \$8; 5\%)}{-(-\$13.16)} = \frac{\$13.92}{\$13.16} \approx 1.058$$
- Capital Budgeting Rule:
$$\text{Invest if } \mathrm{PI} > 1. \text{ Reject if } \mathrm{PI} < 1.$$
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: Payback

- 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	

Advantage of Payback

- 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.
- In a perfect market, you know what these cash flows are. So, trusting managers is irrelevant.

If used for project accept/reject decisions, many other rules are pretty dumb. They become a little bit smarter if you use them only for useful background information. It can also help in informal conversation, if capital is highly constrained, and/or if financial markets are not at all perfect for you. (Even in this case, a form of NPV with a higher discount rate may be better, though.)

When the other rules are stark, they may make the point that the NPV is very high in an intuitive and forceful manner. For example, a project that delivers all the money back by tomorrow is likely to have a pretty good NPV.

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

Real-Life Capital Budgeting Rules

- 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.)

Method	CFO Usage	Yields Correct Answer	Main Explanation
Internal Rate of Return (IRR)	(76%)	Often	Chapter 4
Net Present Value (NPV)	(75%)	(Almost) Always	Chapter 2
Payback Period	(57%)	Rarely	Chapter 4
Earning Multiples (P/E Ratios)	(39%)	With Caution	Chapter 15
Discounted Payback	(30%)	Rarely	Chapter 4
Accounting Rate of Return	(20%)	Rarely	Chapter 15
Profitability Index	(12%)	Often	Chapter 4

Source: Campbell and Harvey, 2001.