Capital Budgeting Rules

(Welch, Chapter 04)

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Maintained Assumptions

Perfect Markets

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.

Perfect Certainty

Equal Returns Per Period

Definition of CBR

A **capital budgeting rule** (CBR) is method to decide which projects to take and which not.

- The term “capital budgeting” is anachronistic. It is also ubiquitous.

The NPV CBR

Take Project Iff $NPV > 0$**.**

The NPV CBR is *the* correct rule in *a* PCM.

Practical Rules?

What about more practical rules?

- No other rule is used more in practice than NPV.
  - runner-up: IRR (explained below)
- Other CBRs can occasionally help intuition.
  - They can only be either redundant or wrong.
  - Sometimes badly so. Yet, some are still in use, so you should learn about them.
  - Sometimes useful in an ICM.

Why is NPV the Best Rule?

- The simplest scenario is “PCM under certainty.”
  - Because any other decision throws money away, they are like anti-arbitrage against yourself.
- As markets get closer to PCM-Certainty, any other good CBR rule must converge to the NPV decision.

Metaphysics

How easy should it be to find positive-NPV projects in *a perfect* world?

- Positive NPV projects should be hard to find *unless* you have unique resources.
- In *a* PCM with certainty, positive NPV projects are near-equivalents of "arbitrage."
- EQBM: If positive NPV projects were abundant, then the opportunity CoC would adjust up.

Example: Investment Decisions

- You have $1 million.
- The prevailing interest rate is 20% per annum.
- You can build a plant with an NPV of $2 million.
- But it takes so long to recoup that you will be dead by the time the plant returns any money.

- Would you build it?

Investments vs Consumption

Does the project's value depend on *when* you need cash?

Separation

Can you make your decision on investment and consumption choices separately, or do you need to make them jointly?

Investment Decisions and Identity

Does project value depend on who you are?

- i.e., on your identity as the owner?

Short-Term Mistakes in CF vs CoC

- Consider a 1-Year Project.
- The correct (expected) cash flow is $500.
- The correct CoC is 20%.
- Is it worse to commit a mistake estimating cash flows or the CoC?

Long-Term Mistakes in CF vs CoC

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

Holding Rates of Return

What is your (holding) RoR for a project that has the following cash patterns:

1. it costs $13.16 million,
2. it pays $7 million next year,
3. it pays another $8 million the year after?

The *Internal Rate of Return*

You need a measure that generalizes the RoR to more than one inflow and one outflow.

The best and most common such measure is the **internal rate of return** (**IRR**).

- In the context of bonds, the IRR is called the **Yield-To-Maturity** (**YTM**). YTM $\equiv$ IRR.

IRR is both in wide use and quite useful. You *must* understand it.

IRR Algebraic Definition

The **IRR** of *a* project is *a rate-of-return-like*-number which sets the NPV = 0.

Definition:

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

IRR Example

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

Solve:

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

Is 9% the correct IRR?

IRR and NPV

Change of Project.

Cash Flows:

1. −$100
2. +$5
3. +$10
4. +$120.

If the CoC is 12%, is this a 0-NPV project?

Graph: IRR

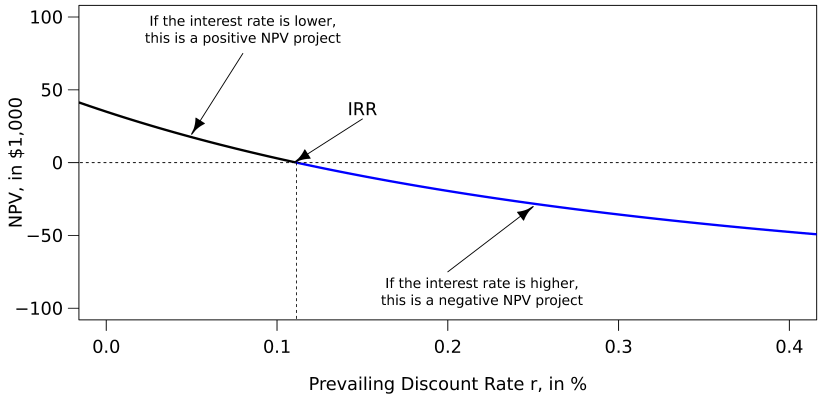


Figure 1: irr

IRR and Rates of Return

A (Holding) RoR is obtained from investing C_0 and later receiving C_1.

- It is not defined for cases with more than one inflow and one outflow.
- An IRR is *not* (necessarily) a RoR.

With only one inflow and one outflow, the IRR *is* the RoR.

- Ergo, IRR is a generalization of the RoR.
- Every RoR is necessarily an IRR.

IRR as "Summary Statistic"

IRR is a "characteristic" of a project's cash flows.

- It is a mapping from a set of many cash flows into one single number.
- ...just like the average, standard deviation, or duration of cash flows.
- it is *sort of* a "time-weighted average RoR intrinsic to a set of cash flows."

The Concept of IRR

- A project with a higher IRR is typically considered more "profitable".
- Multiplying every cash flow by the same factor (positive or negative) does not change the IRR.
  - IRR is invariant to scale.
  - This will play an important role below.

Finding the IRR

There is no general closed-form solution for IRR with many cash flows.

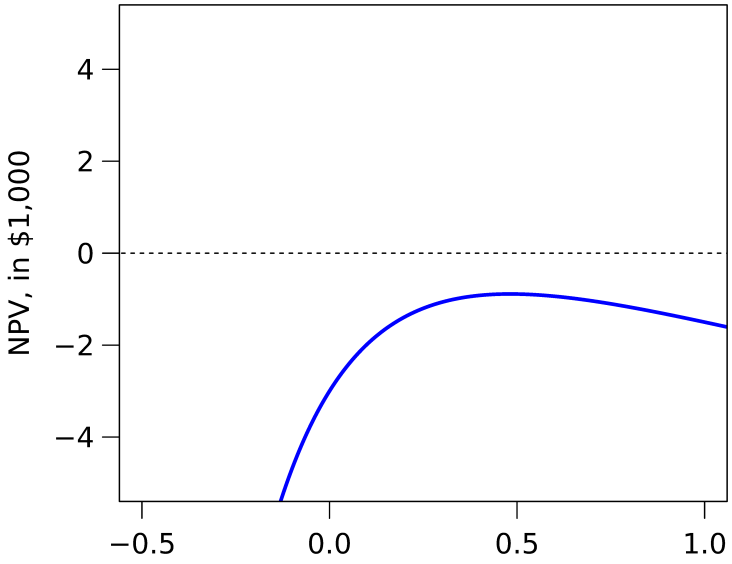
- The IRR is the zero-point of *a* t-order polynomial.
- With three or more cash flows, this is *a* mess or impossible.
- Manual iteration = intelligent trial-and-error.
- Easy for *a* computer. Excel: *IRR()*

Find IRR

1. $C_0 = +\$40$,
2. $C_1 = -\$80$,
3. $C_2 = +\$104$,

What is the IRR?

Graph: No IRR



No IRR

The project is positive or negative NPV for any interest rate. You should accept or reject it *regardless* of the prevailing opportunity CoC.

Check IRR I

1. $C_0 = -\$100$,
2. $C_1 = +\$360$,
3. $C_2 = -\$431$,
4. $C_3 = +\$171.60$,

Is **10%** the IRR?

Check IRR II

1. $C_0 = -\$100$,
2. $C_1 = +\$360$,
3. $C_2 = -\$431$,
4. $C_3 = +\$171.60$,

Is **20%** the IRR?

Check IRR III

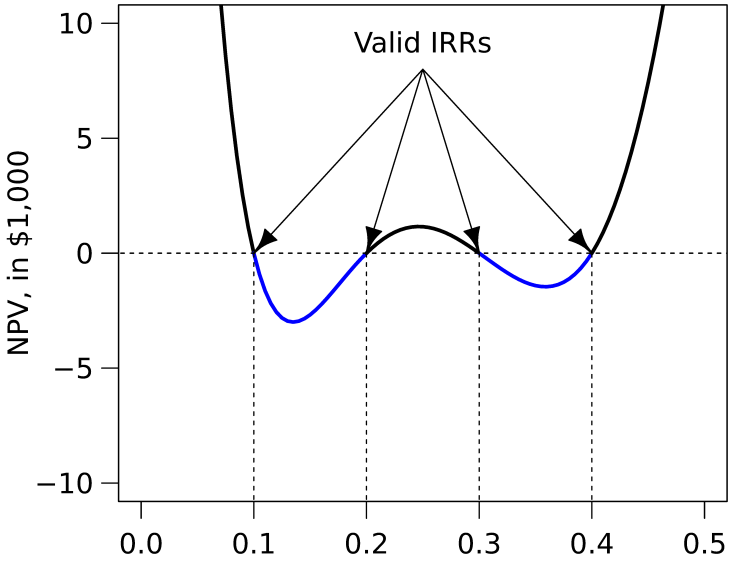
1. $C_0 = -\$100$,
2. $C_1 = +\$360$,
3. $C_2 = -\$431$,
4. $C_3 = +\$171.60$,

Is **30%** the IRR?

Which IRR is Correct?

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

Graph: Multiple IRRs



Nerd: IRR Regions

- These cutoffs define regions of IRR where you would or would not take the project.
- Don't bother with divining IRR.
- Instead, just use NPV!

Unique IRR Warranty

You are guaranteed one unique IRR if you have:

- only negative cash flows upfront.
- only positive cash flows later.

(Or the reverse.)

Multiple IRRs Absurd?

Neg-Pos or Pos-Neg is the usual case for financial bonds and many corporate projects.

- Thus, the YTM is usually unique.

But there are also projects that require big overhauls, maintenance, or cleanups.

You must be aware of the IRR issues, 'lest they bite you one day unexpectedly.

Preview: Promised vs Expected IRR

Uncertainty creates a difference between *promised* and *expected* returns.

- IRR with promised cash flows are promised IRRs.
- Promised cash flows should *never* be used for capital budgeting purposes.
- For NPV or IRR, use *expected* cash flows in the numerator, not *promised* cash flows.

IRR as a CBR I

For a project (first money out):
Invest if IRR > Cost of Capital

For a loan
Borrow if IRR < Cost of Capital

- In case of sign doubts, calculate the NPV!

IRR vs 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.

Biggest IRR CBR Advantage

- You can compute it *before* you need to find out your CoC.
- It characterizes the (real) project *before* you visit potential funders.

Biggest IRR CBR Disadvantage

- Remember the "absence of scale" above?

The *IRR CBR* is useless for comparing mutually exclusive projects.

Project Comparison with IRR

- The prevailing CoC is 20%.
- Consider two exclusive projects:
  1. $C_0 = -\$80$, $C_1 = +\$50$, $C_2 = +\$100$.
  2. $C_0 = -\$85$, $C_1 = +\$100$, $C_2 = +\$45$.
- Try 42%, 47%, 52%, and 57%.
- What are the project IRRs of A and B?
- Which project should you take?

Project Comparison Fail

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

YAP (Yet Another Problem)

- CoC Term Structure.

$$C_0 = -13.16, C_1 = +\$7, C_2 = +\$8$$
$$\Rightarrow IRR \approx 9\% \ .$$

- If your CoC is 8% for 1 year and 10% (annualized) for 2 years, should you take the project?

NPV CBR Over IRR CBR

- IRR is scale insensitive (which causes problems when comparing projects.)
- There may be no IRR.
- There may be multiple IRRs.
- The benchmark CoC may be time-varying.

IRR CBR Over NPV CBR

- Your CoC (the prevailing r) does not enter into the IRR calculation.
- You do not need to recalculate the project value under different cost-of-capital scenarios.
  - Useful if you want to understand your project before talking to investors.

Other CBRs

- Profitability Index
- Payback
- Many worse rules
  - sometimes called “more practical and less academic”
  - often simply “more stupid and confusing.”

The Profitability Index (PI)

1. Project costs $13.16 million,
2. it pays $7 million next year,
3. it pays another $8 million the year after?

The **Profitability Index** is the PV of future cash flows, divided by the cost (made positive).

PI Example

If $r = 20\%$, then

$$\text{PI} = \frac{PV(\$7, \$8; 20\%)}{-(-\$13.16)} = \frac{\$11.39}{\$13.16} \approx 0.87 \ .$$

If $r = 5\%$, then

$$\text{PI} = \frac{PV(\$7, \$8; 5\%)}{-(-\$13.16)} = \frac{\$13.92}{\$13.16} \approx 1.06 \ .$$

The PI CBR

Invest if and only if PI > 1

The PI CBR often gives the same decision as the NPV CBR.

PI CBR Disadvantages

It shares all the same problems as IRR.

- It lacks the concept of project scale.
- Higher PI projects are not necessarily better than lower PI projects.
- PI does not have the main advantage of IRR (which is that the CoC is kept separate).

The Payback CBR

- The “Payback Rule” measures how long it takes to get your money back
- It is the most common ad-hoc rule.
- Here is the Payback CBR:

Take Projects with Shortest Payback Time

How could this possibly go wrong?

Payback Project Comparison

Which project is better?

- Project A: −$1, +$2, $0
- Project B: −$1, $0, +$200

Advantages of Payback?

- Useful if managers cannot be trusted to provide good estimates of far-out future cash flows.
- It is more difficult to deceive on short-term projects.
  - In a PCM, you know what these cash flows are. (Trust is irrelevant.)
  - But in an ICM, is the payback rule really better? (Maybe?)
  - You could also consider other ad-hoc rules, such as NPV with a higher discount rate ("hurdle rate") instead.

Any and All CBRs?

- If a project is *extremely* profitable or unprofitable, most rules will come out with the same recommendation.
  - Even a stopped clock gives the right answer twice a day.

Payback Examples and Rents

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

- What businesses have short payback periods?
- What businesses are highly profitable?
- What are “economic rents”?
- What creates “economic rents”?

Other "Practical" CBRs

- Used less often.
- When used, often badly used.
  - Even a stopped clock gives you the right answer twice a day
- NPV is safe. It works **if** *correctly applied*,
  - but if you are considering an extremely good/bad project, almost any evaluation criterion will give you the same recommendation.

Large Firms

Method	Usage	Correct?	Chap
NPV	77%	Yes	2
IRR	75%	Often	4
Payback	64%	Rarely	4
Acctg RoR	57%	Rarely	5
Comps	49%	Sometimes	5
Prftblty	39%	Often	4

Small Firms

Method	Usage	Correct?	Chap
Payback	66%	? Rarely	4
Acctg RoR	44%	? Rarely	5
Comps	41%	? Sometimes	5
NPV	40%	? Yes	2
IRR	40%	? Often	4
Prftblty	31%	? Often	4

Other CBRs

- Scenario Analysis (common)
- Real Options (occasional)
- Simulations (rare)
- Adjusted Present Value (rare)