

15.415 Finance Theory

Lecture 3: Capital Budgeting
Under Certainty

Spring 1999

Overview of this Lecture

In Lecture 2, we learned:

- Money has time value.
- The NPV rule. Accept a project if its NPV is positive. If there are many mutually exclusive projects with positive NPV, accept the highest NPV project.
- The appropriate discount rate is your opportunity cost of capital.

In this lecture:

- We take an in-depth look at the NPV rule.
- We study other investment rules, such as payback and IRR.

An Extended Example

We use the following example through most of this lecture. We will intentionally keep the analysis simple so that we can concentrate on the tools.

Suppose that you are considering whether to start a company that fixes the “Year 2000 Problem” for other companies.

- Project 1: Involves hiring mostly experienced programmers away from computer companies to do the work. Big hiring bonuses are needed...
- Project 2: Involves hiring new CS graduates to do the work. Hiring bonuses don't have to be quite so large...

Project 1: Experienced Programmers

	1997	1998	1999	2000	2001	2002
Advertising	-\$350	-\$200	\$0	\$0	\$0	\$0
Labor	-\$1300	-\$1300	-\$1300	-\$1500	-\$600	-\$200
Revenue	\$0	\$1300	\$1800	\$2800	\$1200	\$700
Net	-\$1650	\$-200	\$500	\$1300	\$600	\$500

Project 2: New CS Graduates

	1997	1998	1999	2000	2001	2002
Advertising	-\$350	-\$200	\$0	\$0	\$0	\$0
Labor	-\$750	-\$1000	-\$1100	-\$1400	-\$600	-\$200
Revenue	\$0	\$1300	\$1700	\$2200	\$800	\$300
Net	-\$1100	\$100	\$600	\$800	\$200	\$100

In-Class Exercise

Assuming a discount rate of 8%, calculate the NPV of Projects 1 and 2. Which project do you select?

Payback

The payback period of a project is the number of years it takes for cumulative cash flow to cover the initial investment.

The payback rule is to accept a project if its payback period is below a given cutoff. If there are many mutually exclusive projects below the cutoff, accept the project with shortest payback period.

Problems with Payback

Assume a cutoff of 3 years. What is the payback period of each project? Using payback, which project do you accept?

- Payback does not take into account cash flows after the cutoff.
- Payback does not discount cash flows.

Discounted Payback

The discounted payback rule is to accept a project if the number of years it takes for cash flows to have a positive NPV is below a given cutoff.

Assume a cutoff of 3 years. Using discounted payback, which project do you accept?

Discounted payback does not take into account cash flows after the cutoff.

Internal Rate of Return

The internal rate of return (IRR) of a project is the discount rate in the NPV calculation that makes the NPV equal to zero.

For instance, the IRR of project 1 is defined by

$$\begin{aligned} -1650 - \frac{200}{1+r} + \frac{500}{(1+r)^2} + \frac{1300}{(1+r)^3} \\ + \frac{600}{(1+r)^4} + \frac{500}{(1+r)^5} = 0. \end{aligned}$$

To determine the IRR of a project, we plot the NPV as a function of r .

Graph 1

INSERT GRAPH 1

Graph 2

INSERT GRAPH 2

The IRR rule

The IRR rule is to accept a project if its IRR is above the discount rate. If there are many mutually exclusive projects above the discount rate, accept the project with highest IRR.

Using IRR, is project 1 better or worse than no project?
Is project 2 better or worse than no project?

The Problem with IRR

IRR is a rate specific to a project and not the relevant discount rate. Suppose that project X has a lower IRR than project Y. Does this mean that project Y has a higher NPV than project X?

- Yes, if the discount rate is between the IRR of X and the IRR of Y. The NPV of X is negative and the NPV of Y is positive.
- No, if the discount rate is smaller than the IRR of X. There are two reasons why the NPV of X may be greater.

Pitfall 1: Timing

Using IRR, is project 1 better or worse than project 2?

- Project 1 is a long-lived project. Its NPV increases fast as the discount rate decreases.
- Project 2 is a short-lived project. Its NPV increases more slowly.

Graph 3

INSERT GRAPH 3

Pitfall 2: Scale

You want to buy a new machine. You have a choice between the base model and the deluxe model. The base model is cheaper but less efficient.

Deluxe Model	-\$1600	\$520	\$520	\$520	\$400
Base Model	-\$800	\$200	\$300	\$300	\$300

Scale

Assume that the discount rate is 4%. Using NPV, which model do you buy?

Using IRR, which model do you buy?

- The deluxe model represents an investment of larger scale. Its NPV increases fast as the discount rate decreases.
- The base model is a smaller scale investment. Its NPV increases more slowly.

Graph 4

INSERT GRAPH 4

Multiple IRRs

There are more problems with IRR. A project may have many IRR's.

- If a project has negative and then positive cash flows, it has a unique IRR.
- However, if cash flows change sign more than once there can be multiple IRR's. Can you think of examples of such projects?

Project 3: Satisfaction Guarantee

If you hire the CS graduates, you decide to give a satisfaction warranty. The warranty increases your labor costs, especially after the year 2000. At the same time, it increases your revenues.

	1997	1998	1999	2000	2001	2002
Advertising	-\$350	-\$200	\$0	\$0	\$0	\$0
Labor	-\$750	-\$1000	-\$1100	-\$1400	-\$1550	-\$1900
Revenue	\$0	\$1500	\$2100	\$3100	\$1000	\$500
Net	\$-1100	\$300	\$1000	\$1700	\$-550	-\$1400

Graph 5

INSERT GRAPH 5

Spreadsheets

Two caveats.

- Calculate NPV

`=npv(rate,range)`

Warning: The function discounts the first cash flow. So the range should not include the first cash flow. You can use

`=npv(rate,range)+first cash flow`

- Calculate IRR

`=irr(range)`

Warning: The function does not indicate multiple IRR's. You should use

`=irr(range,guess)`