8.5: Capital Budgeting Decision Techniques

There are three capital budgeting techniques:

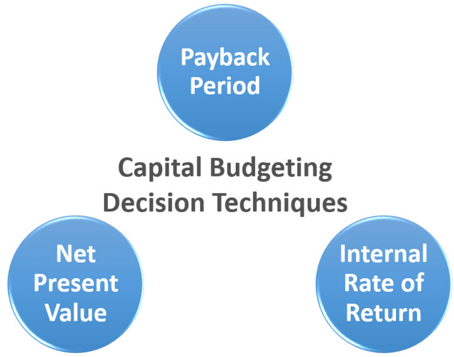

Figure 8.5.1: The three key metrics for capital budgeting decisions are NPV, Payback period and internal rate of return

Note: There are many other additional capital budgeting decision techniques as well, but these are the primary models. Also, be careful about confusing concepts in this chapter as we have introduced (A) four key capital budgeting **criteria**, (B) a four-part capital budgeting **process**, and (C) three capital budgeting decision **techniques**. Oftentimes we will see students mix these up on tests or homework.

A capital budgeting criteria refers to a specific issue we would like the capital budgeting decision process to factor into the decision. For example, the decision rule should consider all relevant cash flows is a criteria.

A capital budgeting process is the set of procedures we want to follow throughout the analysis of a potential capital budgeting process. For example, generating ideas is part of the process.

A capital budgeting technique refers to the way we evaluate whether or not the capital budgeting project being evaluated should be accepted or not. For example, net present value is a technique.

Payback Period

The Payback Period measures the amount of time it would take to earn back the initial investment in the project. Management then decides how long they are willing to wait to recover their investment (critical acceptance level — T) and compares the calculated payback period to the critical acceptance level.

The decision rule for independent projects is to accept all projects that have a payback period less than the critical acceptance level (T). For mutually exclusive projects, the project with the lowest payback period would be chosen (assuming it is below the critical acceptance level)

For example, let's assume that Jim's Printing is considering the purchase of a new printing press. The press will cost $2000 to produce and will generate cash flows of $900 per year for 3 years. What is the payback period for this press? If Jim's assigns a critical acceptance level of 2.0 years, should they accept the project?

- In year one, we earn back $900 and have $1100 of our initial investment to recover
- In year two, we earn back another $900 and still have $200 of our initial investment to recover
- In year three, we will earn more than our initial investment and therefore we know that the payback period is more than two years, but less than three years
- Since we will pay off our initial investment between the 2nd and 3rd year, we divide the amount remaining to be paid off at the start of the 3rd year ($200) by what we will receive in the 3rd year ($900) and find out that it will take us two full years plus 2/9ths (0.22) of the 3rd year to recover our initial investment.
- Therefore, our payback period is 2 + 0.22 years (2.22 years).

Since the Payback Period = 2.22 years which is greater than 2.0 years (our T), we should reject the project.

How well does the payback period meet our 4 criteria? Very poorly. It ignores the time value of money and it may not consider all relevant cash flows (ignoring all cash flows that are after the payback period). Also, the decision rule is arbitrary – what is an acceptable payback period? It also ranks by time instead of shareholder wealth. Because of these flaws, the payback period does not always pick the best project. Despite this, many corporations still calculate the payback period (although usually not as the primary decision tool). Does this mean corporations are stupid? Probably not. What are some situations that you can think of in which the payback period may provide critical information in making a capital budgeting decision? Think about this for a minute before reading further.

There are two primary situations when payback period can be helpful. The first is when the distant cash flows are highly uncertain. For instance, we may project a 6-year life span for the project and find out after two years that the technology behind it has become obsolete and the project must end prematurely. In a situation like this, it would be extremely helpful to have had the entire project paid back by the end of the second year. That way even if we didn't make as much as planned, we at least recovered our investment. The second situation where Payback Period is extremely helpful is when our firm is facing significant financial problems. Consider a highly profitable long-term investment that has very low cash flows in the first couple years and high cash flows in the later years. Can we afford to undertake such an investment if we are having financial problems? Probably not, there is too much of a chance that we will end up bankrupt and out of business before we can get to the part of the project with the high cash flows. For firms suffering from financial distress, projects having a quick payback are important.

Video [Capital Budgeting Part One -Introduction and Payback Period]

Internal Rate of Return

The Internal Rate of Return calculates the average annualized rate of return that we can earn over the lifetime of the project.
The acceptance rule for independent projects is to accept all projects where the IRR is above the required return (hurdle rate) for those projects. If projects are mutually exclusive, accept the one with the highest IRR (assuming it is above the hurdle rate).
Let's look at the IRR of our printing press example

CLEAR WORKSHEET
CF0 = -2000
CF1 = 900
CF2 = 900
CF3 = 900
SOLVE FOR IRR AND GET 16.65%

This is the process we used in Chapter Three Time Value of Money to find the discount rate. Here is a quick review for each calculator:

Calculator Steps to Compute IRR

HP10BII+	**TI-BAII+**	**TI-83/84**

HP10BII+	TI-BAII+	TI-83/84
Step 1: SHIFT C ALL Step 2: -2000 CFj Step 3: 900 CFj Step 4: 3 SHIFT Nj Step 5: SHIFT IRR/YR	Step 1: CF 2nd CLR Work Step 2: -2000 Enter ↓ Step 3: 900 Enter ↓ Step 4: 3 Enter Step 5: IRR Step 6: CPT	Go to APPS⇒Finance⇒ Step 1: Select irr(Step 2: Enter the given information in the following format: irr(CF0,{CF Stream},{CF Frequencies} irr(-2000,{900,900, 900},{1,1,1} Step 3: ALPHA SOLVE

Should we accept the project? Let's assume that the project had a required return of 10%. Given this information, we would accept the project because the IRR is greater than the required return (or hurdle rate). This means that we are earning more than we need to compensate us for the risk we are assuming when we undertake the project.

How well does the IRR meet our 4 criteria? Very well if projects are independent. If projects are mutually exclusive, not so well. IRR incorporates the time value of money and considers all relevant cash flows. We can adjust for risk by adjusting our hurdle rate (the minimum acceptable rate of return for the project). If projects are independent (and there is no crossover problem – see below), the IRR will always make the right decision. However when projects are mutually exclusive, it will not always rank the projects correctly (again, see below). Despite this flaw, is used quite frequently as a capital budgeting techniques (although few firms use it in isolation).

Video [Capital Budgeting Part Two -Calculating Internal Rate of Return]

Crossover (Multiple IRR) Problem

If cash flows for a project crossover more than once (go from negative in one period to positive in the next or vice-versa) then the IRR will have more than one mathematically valid solution. For projects with a crossover problem, the IRR cannot be used. For instance, consider a project with the following cash flow stream:

CF0 = -$100
CF1 = $180
CF2 = $0
CF3 = $0
CF4 = $0
CF5 = $0
CF6 = $0
CF7 = -$100

The project has two IRR's (4.9% and 76.7%). With two solutions, it is unclear whether to accept or reject the project, so we use NPV analysis instead. IRR is unreliable in this situation.

Size Problem and Reinvestment Rate Problem

If projects are mutually exclusive, the IRR can provide invalid rankings due to two problems. First, if the projects are of different sizes (the size problem). Second, if the timing of cash flows is vastly different (one project has cash flows come in evenly throughout the payback period and the other generates low cash flows early on and high cash flows near the end – or other such differences). This is referred to as the reinvestment rate problem. I will explain each of these in detail below, however, it is important to note that these two problems are only relevant when dealing with mutually exclusive projects. If we are dealing with independent projects, they may still impact the rankings but they will not cause us to make an incorrect accept/reject decision.

Size Problem

The issue with the size problem is related to IRR's focus on rate of return instead of value generation in terms of dollars. Consider a situation where you had the choice of two projects. Project A cost $1 today and would return $2 at the end of 1 year. Project B cost $1000 and will return $1500 at the end of 1 year. The first project has a 100% IRR while the second project only has a 50% IRR. At first glance, it appears that Project A is twice as good. However, if you could only take one of these two projects, which would be better? Clearly Project B is a better choice in that you will make $500 beyond your initial investment. If you took Project A, while you earned a higher return you would only make enough profit to visit the $1 menu at your local fast-food chain. When we can only choose one of the available projects, it is not important to identify which project generates the highest rate of return, but instead which project generates the most value. A high rate of return on a small investment is not likely to be as valuable as a moderate rate of return on a large investment. We can recognize the potential for a size problem in evaluating capital budgeting projects by looking at the initial investment. If initial investment sizes are very close, we likely will not encounter a size problem. If initial investments are vastly different, we need to be aware of the size problem and use NPV if dealing with mutually exclusive projects.

Reinvestment Rate Problem

The reinvestment rate problem is not as intuitive as the size problem. The reinvestment rate problem is a function of the process by which the IRR is generated mathematically. In order to calculate the IRR, the calculator assumes that all cash flows received throughout the projects life will be reinvested at the IRR. For instance, let's assume that you have the following project

CF0 = -$1000
CF1 = $800
CF2 = $400
CF3 = $300

This gives us an IRR of 29.02% (in other words, we are expecting to earn an average rate of return of 29.02% per year over the next three years on our $1000 investment that we are making today). However, in order for this IRR to be realized, we will need to take the $800 that is generated at the end of year one and reinvest it somewhere for the remaining two years at 29.02%. Is this realistic? Well, how many investments do you know that pay nearly 30% rates of return? Probably not too many. As such, our average return is biased upwards (as we will likely earn much less than the 29% needed on reinvested cash flows). This bias will be greater for projects that are front loaded. The term front loaded refers to projects with higher cash flows early in the project life. The bias is greater here because the faulty reinvestment rate assumption has longer to impact our final answer. The bias is smaller for projects that are back loaded (cash flows coming in primarily later in the project life). Because of this difference in bias, front loaded projects are likely to have an artificially higher IRR than back loaded projects, which can potentially cause us to rank them incorrectly. If we are evaluating mutually exclusive projects with different timing (front loaded vs. back loaded), then we should be careful of the reinvestment rate problem and choose NPV as our decision tool.

Two last comments on the reinvestment rate problem. First, as with the size problem, it is only important when evaluating mutually exclusive projects. It will not distort accept/reject decisions for independent projects. Second, there is a process called Modified Internal Rate of Return (MIRR) that can be used to correct this issue. However, it is beyond the scope of this class and we will not be covering it.

Net Present Value

The Net Present Value measures the value added by investing in the project. Specifically, the NPV is equal to the present value of all cash flows less the initial investment.

The decision rule for independent projects is to accept all projects with a positive NPV. For mutually exclusive projects, accept the project with the highest positive NPV.

Let's consider the printing press example above, what is its NPV (assume the required return on the project is 10%, just like when we did the IRR analysis)?

CLEAR WORKSHEET
CF0 = -2000
CF1 = 900
CF2 = 900
CF3 = 900
I/YR = 10
SOLVE FOR NPV AND GET $238.17

Calculator Steps to Compute NPV

HP10BII+	**TI-BAII+**	**TI-83/84**
Step 1: SHIFT C ALL Step 2: -2000 CFj Step 3: 900 CFj Step 4: 3 SHIFT Nj Step 5: 10 I/YR Step 6: SHIFT NPV	Step 1: CF 2nd CLR Work Step 2: -2000 Enter ↓ Step 3: 900 Enter ↓ Step 4: 3 Enter Step 5: NPV 10 Enter ↓ Step 6: CPT	Go to APPS⇒Finance⇒ Step 1: Select npv(Step 2: Enter the given information in the following format: npv(Rate,CF0,{CF Stream},{CF Frequencies} npv(10,-2000,{900,900, 900},{1,1,1} Step 3: ALPHA SOLVE

Video [Capital Budgeting Part Three -Calculating Net Present Value]

How well does the NPV meet our 4 criteria? Perfectly. The NPV directly addresses the time value of money. It also considers all relevant cash flows. The riskiness of cash flows can be acknowledged by using a higher discount rate for high-risk projects and a lower discount rate for low-risk projects. The decision rule for NPV will always provide the correct decision. NPV is used by almost all firms as a key capital budgeting decision tool.

Capital Budgeting Decision Rule
When evaluating projects always use NPV as the decision maker. Even if PP and IRR conflict with your NPV analysis, go with the project with the highest NPV.

Video [Capital Budgeting Part Four -Analysis of Decision]

NPV Profile

Required Rate of Return	NPV
0%	$700.00
5%	$450.92
10%	$238.17
15%	$54.90
20%	($104.17)
25%	($243.20)

NPV profile is a graph that shows the relationship between a project's NPV and the required return on the project. To draw the NPV profile, we first need the project's NPV at a number of different discount rates. Let's stick with the example above, which requires an initial investment of $2,000 and generates $900 per year for the next three years. Instead of using a single required rate of return of 10%, I allow the rate to change within a range, say from 0% to 25%. For each discount rate, I would record the corresponding NPV value. The table to the right shows some of the results.

Next, we plot these values to create the NPV profile. Make sure to plot discount rates on the x-axis and NPV on the y-axis. For the project in this example, NPV declines as discount rate increases.

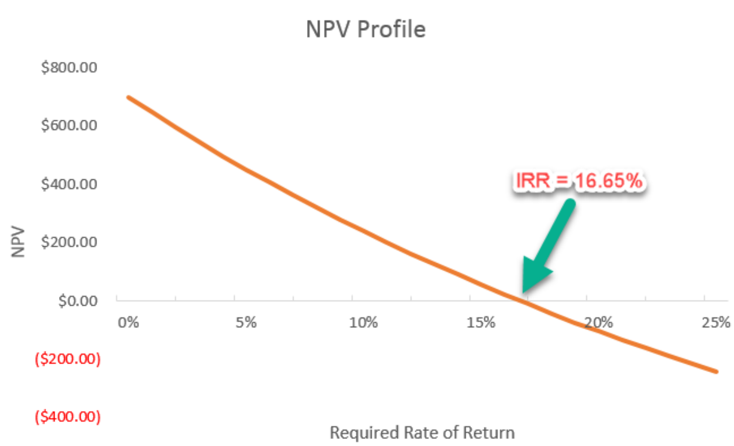

Figure 8.5.2: NPV profile for determining capital decisions

One unique feature about the NPV profile is that it visualizes how IRR is related to NPV. Recall that the IRR of this project is 16.65%, and that is the exact discount rate at which the profile line crosses the horizontal axis. In other words, IRR is in fact the discount rate that makes the project NPV to equal zero.

Now consider two mutually exclusive projects. Project A and Project B require the same initial investment at time 0, but their cash flows in the following years differ.

Year	**Project A**	**Project B**	**Incremental Cash Flow** $\Delta CF = CF_A - CF_B$
0	-$500	-$500	$0
1	$50	$300	-$250
2	$300	$250	$50
3	$400	$150	$250

The figure below shows two NPV profiles – one for A and one for B – and the following are worth noting:

When the discount rate increases, the NPVs from both projects decline.

Each project has only one fixed IRR. The IRR of Project A is lower than that of Project B, no matter what the discount rate is.

The two profiles crosses at a discount rate of 10.50%, which is considered as the crossover rate of the two projects. When the actual cost of capital is lower than the crossover rate, Project A should be taken because it has a higher NPV; when the actual cost of capital exceeds the crossover rate and as long as the NPV is positive, Project B should be accepted.

To find the crossover rate, I first need to compute the incremental cash flows as the difference in the two projects cash flows (see the last column of the table above), and then calculate the IRR based on the incremental cash flows.

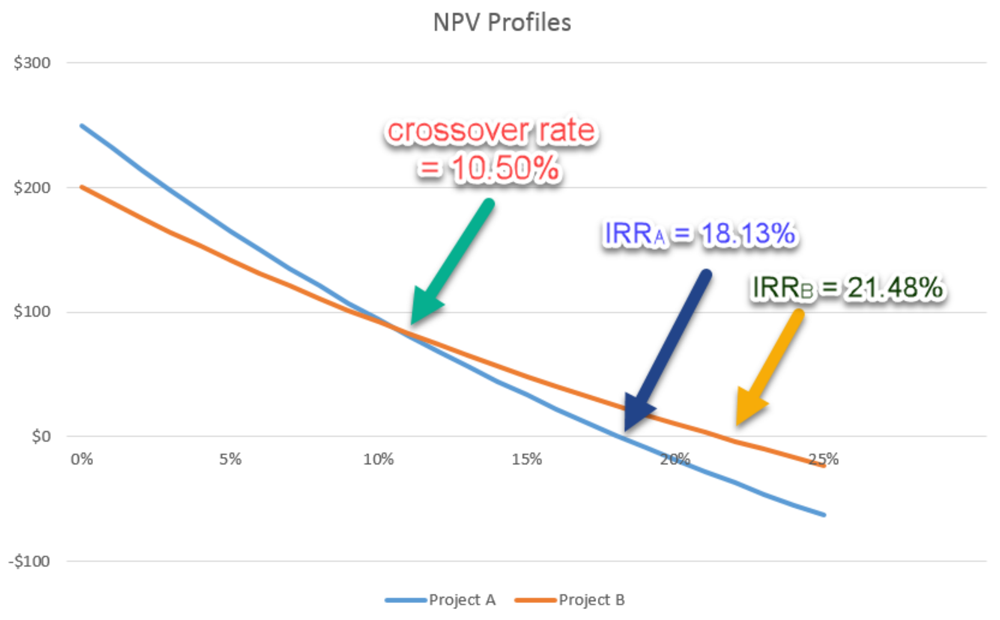

Figure 8.5.3: Copy and Paste Caption here. (Copyright; author via source)