NPV & Capital Budgeting

READ NPV & CAPITAL BUDGETING

Terms for NPV & Capital Budgeting

binding constraint A constraint, such as a budget, human resource, or management-determined constraint, that effectively prevents investment in otherwise desirable (i.e., value-enhancing) projects.

capital budgeting The process by which companies evaluate opportunities and allocate capital; the process by which companies choose which projects to fund.

cost of capital In the context of capital budgeting, the cost of capital usually refers to the discount rate (including both the time value of money and an appropriate risk premium) used to discount expected future cash flows to present value for inclusion in the NPV. For a value maximizer, this cost of capital equals the *opportunity cost of funds*. (Note that in other contexts, this term may mean something different.)

expected cash flows The mean of the probability distribution of uncertain incremental cash flows at a future date.

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hurdle rate The rate chosen by a company for comparison to a project's IRR and which the IRR must exceed for the project to be accepted; alternatively, the discount rate selected by a company for use in an NPV calculation.

internal rate of return (IRR) The discount rate at which the NPV of expected future cash flows equals zero.

net present value (NPV) NPV equals the difference between the present value of expected future cash flows and the immediate required investment (or the present value of required investments if they are spread out over time).

NPV rule An investment criterion: Invest in all projects for which NPV > 0.

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payback period The time it takes for a project to earn back its required investment. *Discounted payback period* discounts the cash flows to present value before accumulating them to compute the payback period.

present value The value of expected future cash flows discounted to the present at an appropriate risk-adjusted rate of return.

profitability index (PI) NPV per dollar invested (NPV/investment). A similar metric may be constructed for other constraints, such as people, as NPV per required person, for example.

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required expected return The lowest expected return at which investors are willing to undertake a risky investment. *See also* opportunity cost of funds.

risk premium The portion of a risk-adjusted discount rate that compensates investors for bearing risk. The risk premium equals the difference between the risk-adjusted discount rate (or expected return) and the risk-free rate.

risk-adjusted discount rate A discount rate composed of the time value of money (the risk-free rate) and a premium for the systematic riskiness of the cash flows being discounted.

terminal value The discounted value at a terminal horizon (a selected point in the future) of all expected cash flows generated by a project beyond the terminal horizon.

NPV and Investment Decisions

2.1 Net Present Value and Investment Decisions

Net present value **(*NPV*)** is, by design, a measure of the value created by a business investment. It is widely used by managers as part of a process for allocating capital among investment opportunities. The important idea behind NPV can be expressed very simply and intuitively: NPV is the difference between how much an investment is worth today and how much it costs. If a manager identifies an asset that is worth $1,000 but which can be acquired for $900, the difference of $100 is the NPV of investing in that asset. It also is a measure of how much the owner's wealth increases when the asset is acquired for $900. In this narrow financial sense, NPV reflects *value creation* (or value destruction)—the change in wealth associated with a specific investment decision.

NPV and Investment Decisions

NPV equals the ***present value*** (***PV***) of future cash flows minus the required upfront investment:

$$NPV = PV - \text{investment}$$

- If NPV < 0, the PV of the project's expected CF < than the cost
  - Management should reject the project.
  - It will destroy value at the firm.

- If NPV > 0, the PV of the project's expected CF > than the cost
  - Management should accept the project.
  - It will create value at the firm.

Guided Example

Pharmco needs to decide if they should buy the right to a new drug created by another company that would generate cash flows shown in the table at a cost of $1 billion. The risk-free rate is 4%. The opportunity cost of fund (discount rate) for this project is found to be 8%. Should Pharmco invest?

Projected Cash Flows for Pharmaco's Proposed Investment ($ in Millions)

Time	t = 0	1	2	3	4	5
Net inflows		$150.0	$180.0	$216.0	$259.2	$311.0
Terminal value						$500.0

(1) Determine the expected cash flows ($E(Cf_t)$) for this project:

1	2	3	4	5

Alternatives to NPV: IRR

2.2.1 Internal Rate of Return for a Single Risky Investment

A project's ***internal rate of return*** (***IRR***) is the discount rate at which its NPV equals zero. Alternatively, one may think of it as a "break-even" discount rate: the rate at which the present value of expected future cash flows is exactly equal to the required investment. To find the IRR, we simply compute NPV for a given project's cash flows and required investment using an arbitrary discount rate. If the resulting NPV is positive (negative), we raise (lower) the discount rate and recompute NPV repeatedly until we find the discount rate at which NPV equals zero.

- IRR of the project < firm's discount rate : reject the project
  - Goes with NPV < 0 and value destruction

- IRR of the project > firm's discount rate : accept the project
  - Goes with NPV > 0 and value creation

Problems associated with IRR

- **More than one IRR (or none):**
  - Future cash flows involve more than one “change of sign”
  - There is no cash outflow (i.e. no cost for investment)
  - Example: Consider the following set of follows with k = 8%

0	1	2	3	4	5
-170	160	160	160	160	-520

  - Find NPV with discount rate = 6.77% and 65.36% respectively
  - NPV @ 6.77% = $0
  - NPV @ 65.36% = $0
  - Which IRR should we use to compare with K = 8%?

Problems associated with IRR

- **IRR decision rule needs to be reversed when outflows follow inflows:**
  - Early cash inflow(s) followed by later cash outflows
  - Occurs even with only one change of signs
  - Example: Consider the following set of follows with k = 8%

0	1	2	3	4	5
1000	-150	-150	-150	-150	-150

  - IRR = -8.9%
  - What does a negative IRR mean in this example, and should the project be accepted?
  - Here the company is being paid $1,000 to then make five payments of $150 at the end of each of the next five years.
  - An IRR less than the discount rate means the NPV should be accepted.

Proper use of IRR

- The IRR is best used when project cash flows exhibit a "conventional" pattern: one or more outflows are followed by a series of cash inflows and no subsequent outflows. This is the circumstance in which the IRR rule is equivalent to the NPV rule for a single project.
- In such cases, IRR calculations also may be an efficient way to gauge the sensitivity of NPV—and hence, the "go or no-go" investment decision—to the discount rate.
- The IRR should be used carefully or not at all when the cash flow pattern is unconventional, particularly when the sign of the cash flows changes more than once.

Alternatives to NPV: Payback Period

- **Payback Period:** the length of time it takes to recover the original investment in a project; In other words, how long does it take to break-even
- If a project has a $100 initial outlay, and generates $25 annual cash flow thereafter, then its payback period is <u>4</u> years
- Project should be <u>accepted/rejected </u>if payback period is less than or equal to a targeted length of time
- Straight-forward to compute and understand
- Intuitive way to acknowledge time value of money
- What are the negatives?

Problems associated with Payback Period

- **Choosing an appropriate target payback period:**
  - No economic basis in picking targeted payback period
  - Payback relies on timing rather than value creation in making decisions
  - Payback-based rule is unlikely to be value-maximizing
  - A shorter payback period <u>does/ does not</u> imply that the project will generate more wealth
- **Payback is shortsighted:**
  - Managers and investors do like to know the payback period
  - Still decisions should be made on the NPV criterion

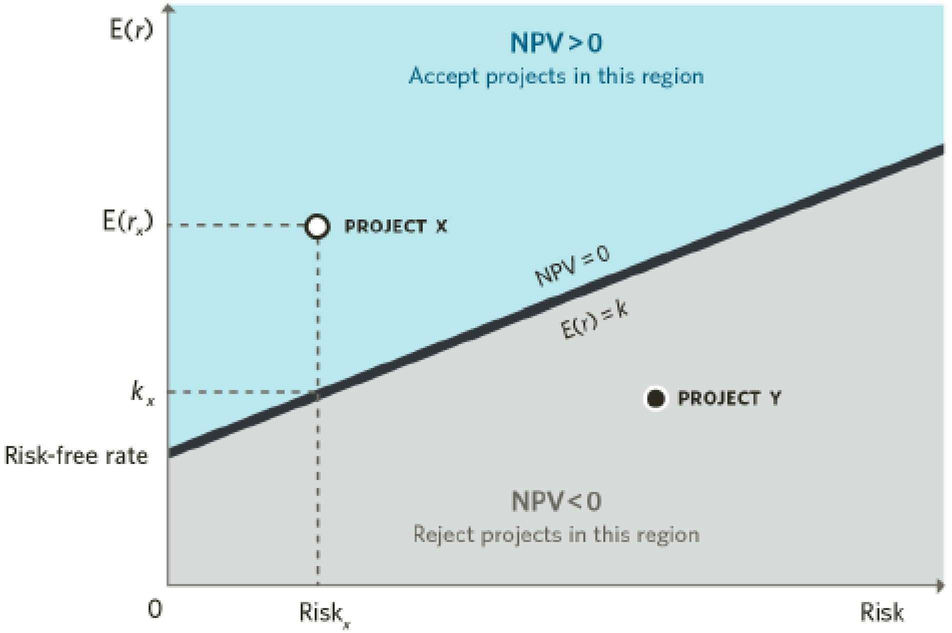
NPV, Project Risk & Expected Return

2.3 NPV, Project Risk, and Expected Return

In general, investment choices may be analyzed in terms of either values (expressed in units of currency) or returns (expressed in percentages). An investor considering whether to buy a share of stock, for example, may ask, "What is the highest price I am willing to pay for this share?" Or, equivalently, "What is the lowest expected return I am willing to accept on this investment?" These two questions lead to the same investment decision. This should sound familiar; we saw earlier that in some circumstances the NPV rule and the IRR rule are equivalent. But then we noted potential problems with IRR (e.g., sometimes there may be no IRR or multiple IRRs). We avoid these problems if we restate the IRR rule as an expected return rule: Invest if the expected return on a project exceeds its required expected return.

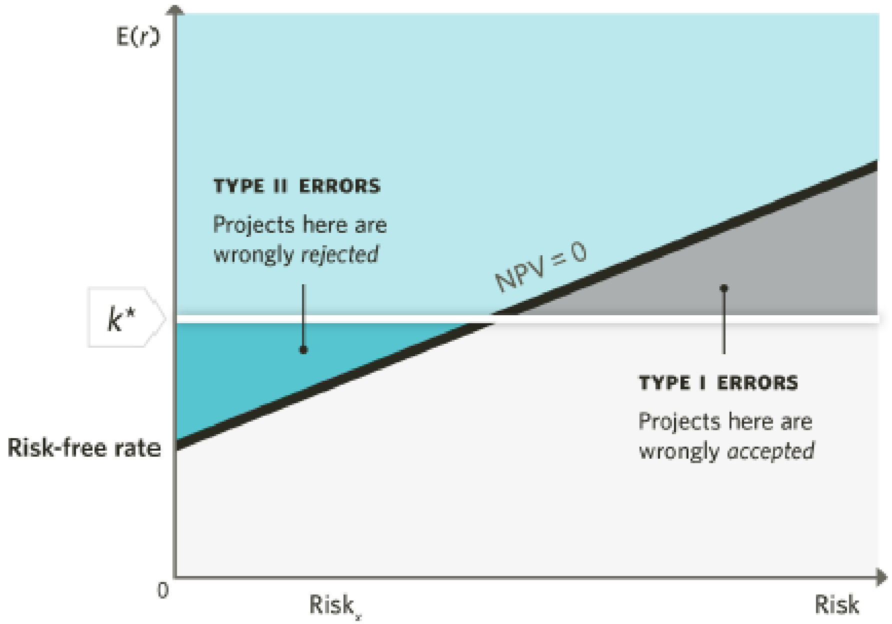
Investment Projects Plotted According to Expected Return and Risk

- Here is a plot of return vs hurdle rate for projects.
- For some companies, all projects have similar risk.
- For other companies, project vary in risk– some are low, some are medium, some are high.
- The black line -- The higher the risk of the project, the higher is the hurdle rate.
- The black line– also the zero-NPV line.
- You would accept/reject projects above the zero-NPV line and accept/reject projects below the zero-NPV line



Single VS Multiple Hurdle Rates

- What are the consequences of using a single hurdle rate in evaluating all projects?
- Suppose a single hurdle rate K* is used for all projects when projects have differing risk levels
- Type I errors: wrongly accepted projects that would destroy value since required expected return is lower than discount rate
- Type II errors: wrongly rejected projects that would actually create value since required expected return is higher than discount rate



Capital budgeting with constraints

3.2 Capital Budgeting with Constraints

So far we have argued that NPV is a good way to measure the wealth a project may be expected to create and that a firm can maximize value by adopting the NPV rule; that is, by investing in all projects for which NPV > 0. In the real world, many companies do not do this. Specifically, they deliberately forgo some apparently positive-NPV projects. Among a number of possible reasons for this, we focus on one here: the existence of one or more ***binding constraints***. Perhaps the most common real-world constraint is a *budget constraint*—a limit on how much a firm can invest in a single period. When investment funds are limited, some valuable projects may go unfunded. The question then is, which one(s)?

A Simple Fixed Budget Constraint

- **Fixed Budget Constraint:** There are multiple projects with positive NPVs.
  - Consider the available projects below:

Project	Discount Rate (k)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	NPV	NPV Ranking	IRR	IRR Ranking
A	4.0%	($1,000)	$200	$250	$280	$300	$320	$191.8	4	10.1%	5
B	4.0%	($300)	$60	$75	$84	$90	$96	$57.5	6	10.1%	5
C	7.0%	($1,000)	$0	$0	$0	$0	$2,000	$426.0	1	14.9%	4
D	7.0%	($400)	$100	$150	$175	$180	$200	$247.2	3	25.5%	1
E	10.0%	($1,000)	$500	$700	($700)	$550	$600	$255.3	2	20.2%	3
F	10.0%	($500)	$620	$0	$0	$0	$0	$63.6	5	24.0%	2

  - All the projects above have positive NPVs.
  - The total cost or upfront outlay is $4,200 in thousands or $4.2M.
  - Managers have a budget of only $2,000 in thousands or $2M.
  - Determine the projects you would invest in based on NPV rule. How many projects would you invest in and what is the value created by investing in these projects?

ANS: Invest in projects C and E based on NPV rule. You can only invest in two projects given $2,000. value created = 426 + 255.3 = **$681.3**

A Simple Fixed Budget Constraint

Project	Discount Rate (*k*)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	NPV	NPV Ranking	IRR	IRR Ranking
A	4.0%	($1,000)	$200	$250	$280	$300	$320	$191.8	4	10.1%	5
B	4.0%	($300)	$60	$75	$84	$90	$96	$57.5	6	10.1%	5
C	7.0%	($1,000)	$0	$0	$0	$0	$2,000	$426.0	1	14.9%	4
D	7.0%	($400)	$100	$150	$175	$180	$200	$247.2	3	25.5%	1
E	10.0%	($1,000)	$500	$700	($700)	$550	$600	$255.3	2	20.2%	3
F	10.0%	($500)	$620	$0	$0	$0	$0	$63.6	5	24.0%	2

- Determine the projects you would invest in based on IRR rule.
- How many projects would you invest in and what is the value created by investing in these projects?
- <u>ANS: Invest in D,F, and E based on IRR rule. Value created = 247.2 + 63.6 + 255.3 = **$566.1**</u>
- Thus IRR is not the solution when we have a budget constraint.
- It turns out that NPV alone is also not sufficient because each project's initial outlays are different and we have a budget constraint

A Simple Fixed Budget Constraint

Project	Discount Rate (k)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	NPV	NPV Ranking	IRR	IRR Ranking
A	4.0%	(\$1,000)	\$200	\$250	\$280	\$300	\$320	\$191.8	4	10.1%	5
B	4.0%	(\$300)	\$60	\$75	\$84	\$90	\$96	\$57.5	6	10.1%	5
C	7.0%	(\$1,000)	\$0	\$0	\$0	\$0	\$2,000	\$426.0	1	14.9%	4
D	7.0%	(\$400)	\$100	\$150	\$175	\$180	\$200	\$247.2	3	25.5%	1
E	10.0%	(\$1,000)	\$500	\$700	(\$700)	\$550	\$600	\$255.3	2	20.2%	3
F	10.0%	(\$500)	\$620	\$0	\$0	\$0	\$0	\$63.6	5	24.0%	2

- Is there another combination of investment that would yield a higher total NPV?
- Consider investing in projects C,D and F.
- The total outlay would be \$1,900.
- The total NPV is **\$736.8**, higher than 681.3 with a lower initial outlay.
- You would like to $maximize(\sum NPV_i)\ with\ outlay \leq budget$

- How do managers find the highest total NPV when capital is constrained? The use of the profitability index in the initial allocation works.

Profitability Index – How Compute?

- Profitability Index: measures relative efficiency of value creation among projects
- It helps us arrive at a useful ranking of the various projects
- $\text{Profitability Index} = \dfrac{\text{NPV}}{\text{Investment}}$
- Profitability index tells us the NPV per dollar of investment; In other words, PI demonstrates investment efficiency—how much value we create per dollar invested at a project
- Rank projects A-F based on Profitability Index:

Project	Year 0	NPV	NPV Ranking	PI	PI Ranking
A	($1,000)	$191.8	4		
B	($300)	$57.5	6		
C	($1,000)	$426.0	1		
D	($400)	$247.2	3		
E	($1,000)	$255.3	2		
F	($500)	$63.6	5		

Profitability Index – Use at the beginning to allocate capital

- Project D has the highest PI ranking at 1 cost = 400
- Project C has the next highest PI ranking at 2 cost = 1,000
- We cannot undertake project E (limited capital)
- We can afford B or F
- Pick the one with the highest NPV this time, F cost = 500

Project	Year 0	NPV	NPV Ranking	PI	PI Ranking
A	($1,000)	$191.8	4	0.19	4
B	($300)	$57.5	6	0.19	4
C	($1,000)	$426.0	1	0.43	2
D	($400)	$247.2	3	0.62	1
E	($1,000)	$255.3	2	0.26	3
F	($500)	$63.6	5	0.13	6

Mutually Exclusive Projects

You are given two mutually exclusive projects X and Y with the same risk. The risk-adjusted discount rate is 14.9%. Which project would you invest in?

Mutually exclusive means the machines do the same thing. One machine might cost more but last longer.

Most people can afford one car, or at least one car per driver. If the purchaser is deciding to either buy a car or lease a car, but not both, that is a mutually exclusive decision.

Project	Outlay	Year 1	NPV	IRR
X	($34,000)	$40,000	$426	14.9%
Y	($18,000)	$21,500	$255.3	20.2%