Chapter 13

Capital Budgeting Techniques

Learning Objectives

After studying Chapter 13, you should be able to:

- Understand the payback period (PBP) method of project evaluation and selection, including its: (a) calculation; (b) acceptance criterion; (c) advantages and disadvantages; and (d) focus on liquidity rather than profitability.
- Understand the three major discounted cash flow (DCF) methods of project evaluation and selection – internal rate of return (IRR), net present value (NPV), and profitability index (PI).
- Explain the calculation, acceptance criterion, and advantages (over the PBP method) for each of the three major DCF methods.
- Define, construct, and interpret a graph called an “NPV profile.”
- Understand why ranking project proposals on the basis of IRR, NPV, and PI methods “may” lead to conflicts in ranking.
- Describe the situations where ranking projects may be necessary and justify when to use either IRR, NPV, or PI rankings.
- Understand how “sensitivity analysis” allows us to challenge the single-point input estimates used in traditional capital budgeting analysis.
- Explain the role and process of project monitoring, including “progress reviews” and “post-completion audits.”

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Topics

- Project Evaluation and Selection
- Potential Difficulties
- Capital Rationing
- Project Monitoring
- Post-Completion Audit

Project Evaluation: Alternative Methods

- Payback Period (PBP)
- Internal Rate of Return (IRR)
- Net Present Value (NPV)
- Profitability Index (PI)

Proposed Project Data

Julie Miller is evaluating a new project for her firm, *Basket Wonders (BW)*. She has determined that the after-tax cash flows for the project will be $10,000; $12,000; $15,000; $10,000; and $7,000, respectively, for each of the Years 1 through 5. The initial cash outlay will be $40,000.

Independent Project

- For this project, assume that it is independent of any other potential projects that *Basket Wonders* may undertake.

- Independent -- A project whose acceptance (or rejection) does not prevent the acceptance of other projects under consideration.

Payback Period (PBP)

0	1	2	3	4	5
-40 K	10 K	12 K	15 K	10 K	7 K

PBP is the period of time required for the cumulative expected cash flows from an investment project to equal the initial cash outflow.

Payback Solution (#1)

0	1	2	3 (a)	4	5
-40 K (-b)	10 K	12 K	15 K	*10 K* (d)	7 K
Cumulative Inflows	10 K	22 K	*37 K* (c)	47 K	54 K

PBP = a + (b - c) / d
= 3 + (40 - 37) / 10
= 3 + (3) / 10
= 3.3 Years

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Payback Solution (#2)

0	1	2	3	4	5
-40 K	10 K	12 K	15 K	10 K	7 K
-40 K	-30 K	-18 K	-3 K	7 K	14 K

Cumulative Cash Flows

PBP = 3 + (3K) / 10K
= 3.3 Years

Note: Take absolute value of last negative cumulative cash flow value.

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PBP Acceptance Criterion

The management of *Basket Wonders* has set a maximum PBP of 3.5 years for projects of this type.

Should this project be accepted?

Yes! The firm will receive back the initial cash outlay in less than 3.5 years. [3.3 Years < 3.5 Year Max.]

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PBP Strengths and Weaknesses

Strengths:

– Easy to use and understand

– Can be used as a measure of liquidity

-- Easier to forecast ST than LT flows

Weaknesses:

– Does not account for TVM

– Does not consider cash flows beyond the PBP

– Cutoff period is subjective

Internal Rate of Return (IRR)

IRR is the discount rate that equates the present value of the future net cash flows from an investment project with the project's initial cash outflow.

$$ICO = \frac{CF_1}{(1+IRR)^1} + \frac{CF_2}{(1+IRR)^2} + \ldots + \frac{CF_n}{(1+IRR)^n}$$

IRR Solution

$$\$40{,}000 = \frac{\$10{,}000}{(1+IRR)^1} + \frac{\$12{,}000}{(1+IRR)^2} + \frac{\$15{,}000}{(1+IRR)^3} + \frac{\$10{,}000}{(1+IRR)^4} + \frac{\$7{,}000}{(1+IRR)^5}$$

Find the interest rate (*IRR*) that causes the discounted cash flows to equal $40,000.

IRR Solution (Try 10%)

$$\$40{,}000 = \$10{,}000(PVIF_{10\%,1}) + \$12{,}000(PVIF_{10\%,2}) + \$15{,}000(PVIF_{10\%,3}) + \$10{,}000(PVIF_{10\%,4}) + \$\ 7{,}000(PVIF_{10\%,5})$$

$$\$40{,}000 = \$10{,}000(.909) + \$12{,}000(.826) + \$15{,}000(.751) + \$10{,}000(.683) + \$\ 7{,}000(.621)$$

$$\$40{,}000 = \$9{,}090 + \$9{,}912 + \$11{,}265 + \$6{,}830 + \$4{,}347$$

$= \$41{,}444$ [*Rate is too low!!*]

IRR Solution (Try 15%)

$$
\begin{aligned}
\$40{,}000 = {} & \$10{,}000(PVIF_{15\%,1}) + \$12{,}000(PVIF_{15\%,2}) \\
+ {} & \$15{,}000(PVIF_{15\%,3}) + \$10{,}000(PVIF_{15\%,4}) \\
+ {} & \$\ \ 7{,}000(PVIF_{15\%,5})
\end{aligned}
$$

$$
\begin{aligned}
\$40{,}000 = {} & \$10{,}000(.870) + \$12{,}000(.756) + \\
& \$15{,}000(.658) + \$10{,}000(.572) + \\
& \$\ \ 7{,}000(.497)
\end{aligned}
$$

$$
\begin{aligned}
\$40{,}000 = {} & \$8{,}700 + \$9{,}072 + \$9{,}870 + \\
& \$5{,}720 + \$3{,}479 \\
= {} & \$36{,}841 \quad \textit{[Rate is too high!!]}
\end{aligned}
$$

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IRR Solution (Interpolate)

$$
.05 \left[X \left[\begin{array}{ll} .10 & \$41{,}444 \\ IRR & \$40{,}000 \end{array} \right] \$1{,}444 \atop \begin{array}{ll} .15 & \$36{,}841 \end{array} \right] \$4{,}603
$$

$$
\frac{X}{.05} = \frac{\$1{,}444}{\$4{,}603}
$$

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IRR Solution (Interpolate)

$$.05 \left[X \left[\begin{array}{ll} .10 & \$41,444 \\ IRR & \$40,000 \end{array} \right] \$1,444 \quad \begin{array}{ll} \\ \\ .15 & \$36,841 \end{array} \right] \$4,603$$

$$X = \frac{(\$1,444)(0.05)}{\$4,603} \qquad X = .0157$$

IRR = .10 + .0157 = .1157 or 11.57%

IRR Acceptance Criterion

The management of *Basket Wonders* has determined that the hurdle rate is 13% for projects of this type.

Should this project be accepted?

No! The firm will receive 11.57% for each dollar invested in this project at a cost of 13%. [IRR < Hurdle Rate]

IRR Strengths and Weaknesses

Strengths:

- Accounts fo TVM
- Considers all cash flows
- Less subjectivity

Weaknesses:

- Assumes all cash flows reinvested at the IRR
- Difficulties with project rankings and Multiple IRRs

Net Present Value (NPV)

NPV is the present value of an investment project's net cash flows minus the project's initial cash outflow.

$$NPV = \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \ldots + \frac{CF_n}{(1+k)^n} - ICO$$

NPV Solution

Basket Wonders has determined that the appropriate discount rate (k) for this project is 13%.

$$NPV = \frac{\$10{,}000}{(1.13)^1} + \frac{\$12{,}000}{(1.13)^2} + \frac{\$15{,}000}{(1.13)^3} + \frac{\$10{,}000}{(1.13)^4} + \frac{\$7{,}000}{(1.13)^5} - \$40{,}000$$

NPV Solution

NPV = $10,000(PVIF$_{13\%,1}$) + $12,000(PVIF$_{13\%,2}$) + $15,000(PVIF$_{13\%,3}$) + $10,000(PVIF$_{13\%,4}$) + $ 7,000(PVIF$_{13\%,5}$) - $40,000

NPV = $10,000(.885) + $12,000(.783) + $15,000(.693) + $10,000(.613) + $ 7,000(.543) - $40,000

NPV = $8,850 + $9,396 + $10,395 + $6,130 + $3,801 - $40,000

= - $1,428

NPV Acceptance Criterion

The management of *Basket Wonders* has determined that the required rate is 13% for projects of this type.

Should this project be accepted?

No! The NPV is negative. This means that the project is reducing shareholder wealth. [*Reject* as *NPV* < *0*]

NPV Strengths and Weaknesses

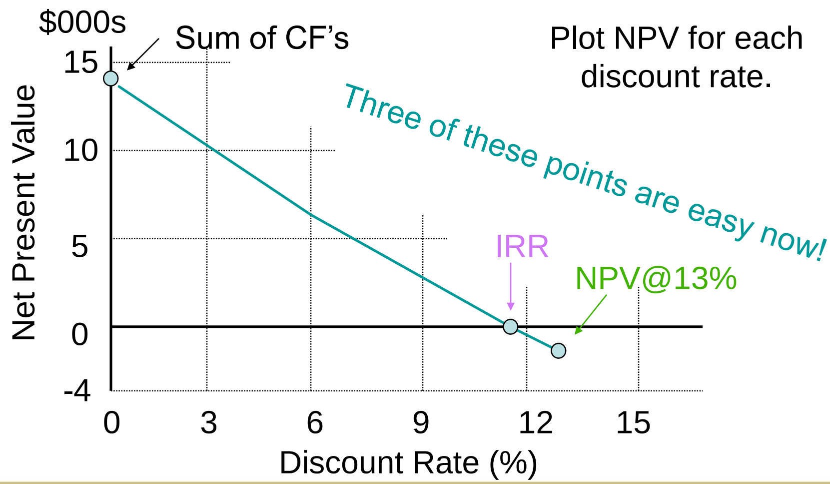
Strengths:

- Cash flows assumed to be reinvested at the hurdle rate.
- Accounts for TVM.
- Considers all cash flows.

Weaknesses:

- May not include managerial options embedded in the project.

Net Present Value Profile



Profitability Index (PI)

PI is the ratio of the present value of a project's future net cash flows to the project's initial cash outflow.

Method #1:

$$PI = \left[\frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \ldots + \frac{CF_n}{(1+k)^n} \right] \div ICO$$

<< OR >>

Method #2:

$$PI = 1 + [\ NPV \ / \ ICO\ ]$$

PI Acceptance Criterion

PI = $38,572 / $40,000
= .9643 *(Method #1, 13-34)*

Should this project be accepted?

No! The PI is less than 1.00. This means that the project is not profitable. [*Reject* as *PI* < *1.00*]

PI Strengths and Weaknesses

Strengths:
- Same as NPV
- Allows comparison of different scale projects

Weaknesses:
- Same as NPV
- Provides only relative profitability
- Potential Ranking Problems

Evaluation Summary

Basket Wonders Independent Project

Method	Project	Comparison	Decision
PBP	3.3	3.5	**Accept**
IRR	11.47%	13%	**Reject**
NPV	-$1,424	$0	**Reject**
PI	.96	1.00	**Reject**

Other Project Relationships

- *Dependent* -- A project whose acceptance depends on the acceptance of one or more other projects.
- *Mutually Exclusive* -- A project whose acceptance precludes the acceptance of one or more alternative projects.

Potential Problems Under Mutual Exclusivity

Ranking of project proposals *may* create contradictory results.

A. Scale of Investment
B. Cash-flow Pattern
C. Project Life

A. Scale Differences

Compare a small (S) and a large (L) project.

	NET CASH FLOWS	
END OF YEAR	Project S	Project L
0	-$100	-$100,000
1	0	0
2	$400	$156,250

Scale Differences

Calculate the PBP, IRR, NPV@10%, and PI@10%.

Which project is preferred? Why?

Project	IRR	NPV	PI
S	100%	$ 231	3.31
L	25%	$29,132	1.29

B. Cash Flow Pattern

Let us compare a *decreasing* cash-flow (D) project and an *increasing* cash-flow (I) project.

	NET CASH FLOWS	
END OF YEAR	Project D	Project I
0	-$1,200	-$1,200
1	1,000	100
2	500	600
3	100	1,080

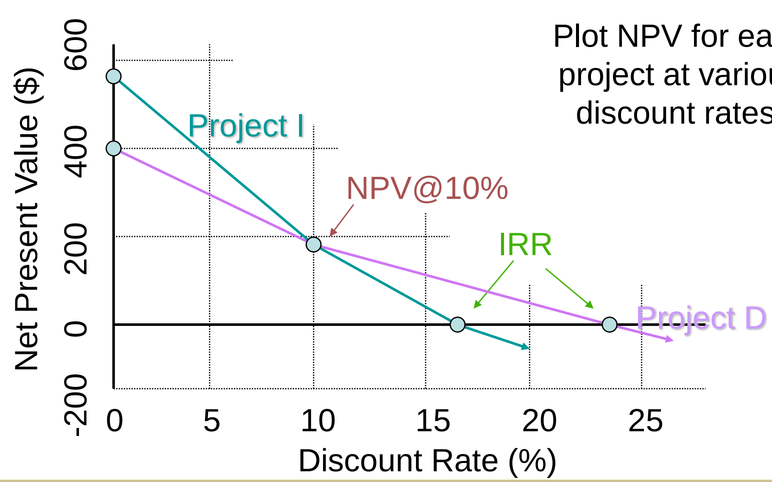
Cash Flow Pattern

Calculate the IRR, NPV@10%, and PI@10%.

Which project is preferred?

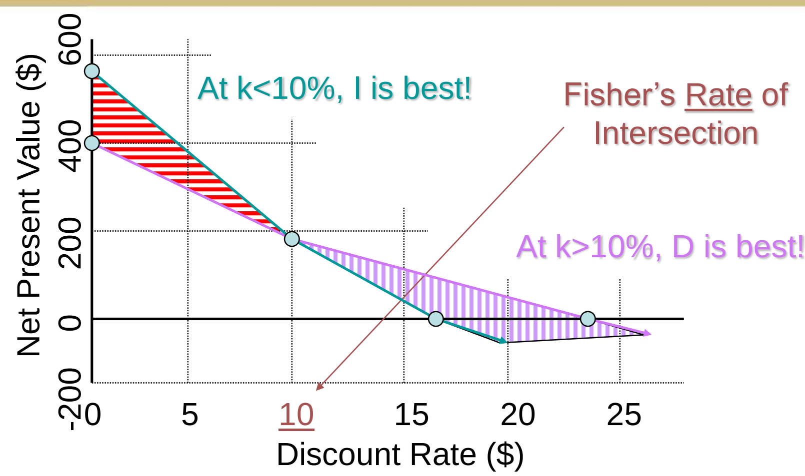
Project	IRR	NPV	PI
D	23%	$198	1.17
I	17%	$198	1.17

Examine NPV Profiles



Plot NPV for each project at various discount rates.

Fisher's Rate of Intersection



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C. Project Life Differences

Let us compare a *long* life (X) project and a *short* life (Y) project.

END OF YEAR	NET CASH FLOWS Project X	Project Y
0	-$1,000	-$1,000
1	0	2,000
2	0	0
3	3,375	0

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Project Life Differences

Calculate the PBP, IRR, NPV@10%, and PI@10%.

Which project is preferred? Why?

Project	IRR	NPV	PI
X	50%	$1,536	2.54
Y	100%	$ 818	1.82

?

Another Way to Look at Things

1. Adjust cash flows to a common terminal year if project "Y" will ***NOT*** be replaced.

Compound Project Y, Year 1 @10% for 2 years.

Year	0	1	2	3
CF	-$1,000	$0	$0	$2,420

Results: IRR* = 34.26% NPV = $818

**Lower IRR* from adjusted cash-flow stream. X is still Best.

Replacing Projects with Identical Projects

2. Use *Replacement Chain Approach* (Appendix B) when project "Y" will be replaced.

0	1	2	3
-$1,000	$2,000		
	-1,000	$2,000	
		-1,000	$2,000
-$1,000	$1,000	$1,000	$2,000

Results: IRR = 100% NPV* = $2,238.17

**Higher NPV, but the same IRR*. Y is Best.

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Capital Rationing

Capital Rationing occurs when a constraint (or budget ceiling) is placed on the total size of capital expenditures during a particular period.

Example: Julie Miller must determine what investment opportunities to undertake for *Basket Wonders (BW)*. She is limited to a maximum expenditure of $32,500 *only* for this capital budgeting period.

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Available Projects for BW

Project	ICO	IRR	NPV	PI
A	$ 500	18%	$ 50	1.10
B	5,000	25	6,500	2.30
C	5,000	37	5,500	2.10
D	7,500	20	5,000	1.67
E	12,500	26	500	1.04
F	15,000	28	21,000	2.40
G	17,500	19	7,500	1.43
H	25,000	15	6,000	1.24

Choosing by IRRs for BW

Project	ICO	IRR	NPV	PI
C	$ 5,000	37%	$ 5,500	2.10
F	15,000	28	21,000	2.40
E	12,500	26	500	1.04
B	5,000	25	6,500	2.30

Projects C, F, and E have the three *largest IRRs*.

The resulting *increase* in shareholder wealth is $27,000 with a $32,500 outlay.

Choosing by NPVs for BW

Project	ICO	IRR	NPV	PI
F	$15,000	28%	$21,000	2.40
G	17,500	19	7,500	1.43
B	5,000	25	6,500	2.30

Projects F and G have the two *largest NPVs*.

The resulting *increase* in shareholder wealth is $28,500 with a $32,500 outlay.

Choosing by PIs for BW

Project	ICO	IRR	NPV	PI
F	$15,000	28%	$21,000	2.40
B	5,000	25	6,500	2.30
C	5,000	37	5,500	2.10
D	7,500	20	5,000	1.67
G	17,500	19	7,500	1.43

Projects F, B, C, and D have the four *largest PIs*.

The resulting *increase* in shareholder wealth is $38,000 with a $32,500 outlay.

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Summary of Comparison

Method	Projects Accepted	Value Added
PI	F, B, C, and D	$38,000
NPV	F and G	$28,500
IRR	C, F, and E	$27,000

PI generates the *greatest increase* in *shareholder wealth* when a limited capital budget exists for a *single period*.

Single-Point Estimate and Sensitivity Analysis

Sensitivity Analysis: A type of "what-if" uncertainty analysis in which variables or assumptions are changed from a base case in order to determine their impact on a project's measured results (such as NPV or IRR).

- Allows us to change from "*single-point*" (i.e., revenue, installation cost, salvage, etc.) estimates to a "*what if*" analysis
- Utilize a "base-case" to compare the impact of individual variable changes
  - E.g., Change forecasted sales units to see impact on the project's NPV

Post-Completion Audit

Post-completion Audit

A formal comparison of the actual costs and benefits of a project with original estimates.

– Identify any project weaknesses
– Develop a possible set of corrective actions
– Provide appropriate feedback

Result: Making better future decisions!

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Multiple IRR Problem*

Let us assume the following cash flow pattern for a project for Years 0 to 4:

-$100 +$100 +$900 -$1,000

How many *potential* IRRs could this project have?

Two!! There are as many potential IRRs as there are sign changes.

** Refer to Appendix A*

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NPV Profile -- Multiple IRRs