MBAS 821: Topic 2

Investment Decisions

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How do companies make investment decisions?

Manufacturing

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Robots and assembly machines at the Tesla factory in Fremont, Calif., June 14, 2018.
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Investment Decisions Overview

- Investment Evaluation Methods
  - Net Present Value (NPV)
  - Internal Rate of Return (IRR)
    - Incremental IRR
  - Payback Period (PP)
  - Profitability Index (PI)
- Strengths and Weaknesses of these measures

Brief Steps of Investment Decision Making

1. Forecast **project cash flows**.

2. Estimate cost of capital *r*, or sometimes refered as **WACC**(Weighted Average Cost of Capital)

   - We will focus more on this in topic 6: Cost of Capital

3. Evaluate projects using one or more methods

   - NPV, IRR, PP, PI

Accept or reject project(s) based on one or more of the evaluation criteria.

Net Present Value (NPV)

NPV: Present value of all future cash inflows discounted at cost of capital *r* minus the initial investment

$$NPV(\text{project}) = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} - C_0$$

C_0: Initial investment for the project
CF_t: Cash flow of project at time t

- NPV investment rules:
  - $NPV > 0 \rightarrow$ Accept project
  - $NPV < 0 \rightarrow$ Reject project
  - If projects are mutually exclusive (i.e. Picking one project out of several projects), choose the project with the highest NPV.

NPV: an Example

Bob's Shoes is evaluating two possible expansion projects, to New York and/or to Chicago. Cost of capital is 10%. Below are the expected cash flows of the project:

Estimated Cash Flows		
Time	New York	Chicago
0	-1,000	-1,000
1	500	100
2	400	400
3	300	400
4	100	600
WACC = 10%/year		

$$NPV(\text{New York}) = \frac{500}{1.1} + \frac{400}{1.1^2} + \frac{300}{1.1^3} + \frac{100}{1.1^4} - 1,000 = \$78.82$$

$$NPV(\text{Chicago}) = \frac{100}{1.1} + \frac{400}{1.1^2} + \frac{400}{1.1^3} + \frac{600}{1.1^4} - 1000 = \$131.82$$

What would you recommend?

The Decision

- If projects are *independent* and the firm has sufficient capital to finance both projects, **accept all positive NPV projects**!
    - Therefore, they should expand to both Chicago and New York.
- If the porjects are mutually exclusive (can only accept one or another), **choose the investment with the highest NPV**!
    - Therefore, they should expand to Chicago. ($131.82 > $78.82)

Note: the NPV of a project typically declines as the discount rate/cost of capital rises. (Any exceptions?)

What is NPV and is it any good?

- NPV represents the expected change in firm value from undertaking the project.
  - $NPV > 0 \rightarrow$ Increases firm value
  - $NPV < 0 \rightarrow$ Destroys firm value
- Strengths of NPV
  - NPV takes into account of all future cash flows related to the project.
  - NPV discounts cash flows correctly.
  - NPV tells you exactly how much value is added to the firm.

Internal Rate of Return (IRR)

IRR is the *hypothetical* discount rate that makes the NPV of a project equal to 0.

$$\sum_{t=1}^{T} \frac{CF_t}{(1+IRR)^t} - C_0 = 0$$

Note: For prjects with multiperiod cash flows, it is difficult to calculate the IRR algebrically. You can use the *graphing* method, a *financial calculator*, or an *online IRR calculator* to find the IRR.

IRR investment rules:

- $IRR > r \rightarrow$ Accept project
- $IRR < r \rightarrow$ Reject project
- IRR rule will often, *but not always*, coincide with the NPV rule.

IRR: an Example

Estimated Cash Flows		
Time	New York	Chicago
0	-1,000	-1,000
1	500	100
2	400	400
3	300	400
4	100	600
WACC = 10%/year		

New York:

$$-1000 + \frac{500}{1+r} + \frac{400}{(1+r)^2} + \frac{300}{(1+r)^3} + \frac{100}{(1+r)^4} = 0 \qquad IRR = 14.49\%$$

Chicago:

$$-1000 + \frac{100}{1+r} + \frac{400}{(1+r)^2} + \frac{400}{(1+r)^3} + \frac{600}{(1+r)^4} = 0 \qquad IRR = 14.82\%$$

Therefore, pick Chicago (IRR = 14.82%) if the projects are mutually exclusive. Accept both if the projects are independent (Both IRRs of New York and Chicago projects are greater than 10%).

IRR: Complications

- Does the NPV rule always give the same answer as the IRR rule?
- Problems with the IRR approach:
  - Issues affecting ***both*** independent and mutually exclusive projects:
    - "Investing" vs "Financing"
    - Multiple IRR solutions
  - Issues affecting ***only*** mutually exclusive projects:
    - The scale problem
    - The timing problem

Investing vs Financing: an Example

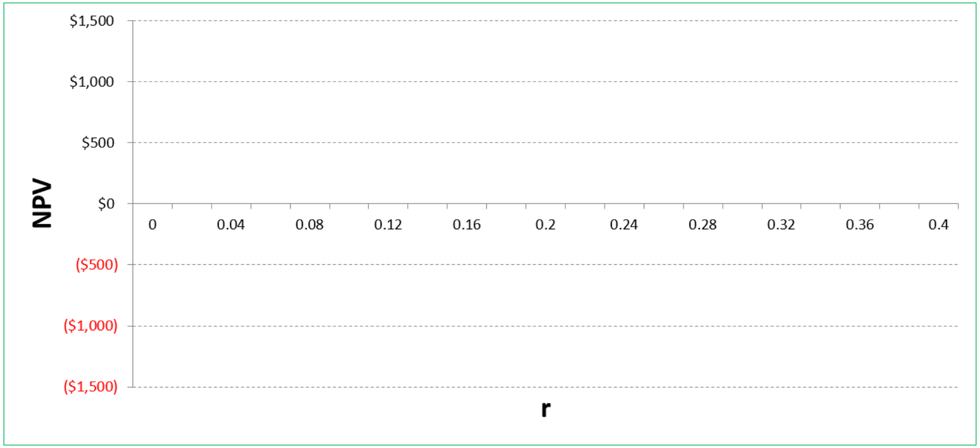
Prof. Riordan was recently asked to write a textbook for intro to finance.

He took an up front payment of $1,000,000 and was expected to deliver a completed text in 3 years. He figures that based on his consulting rates it will cost him $500,000 a year to complete the book. If current interest rates are 10%, based on the IRR criteria, what should he have done? What about the NPV method?

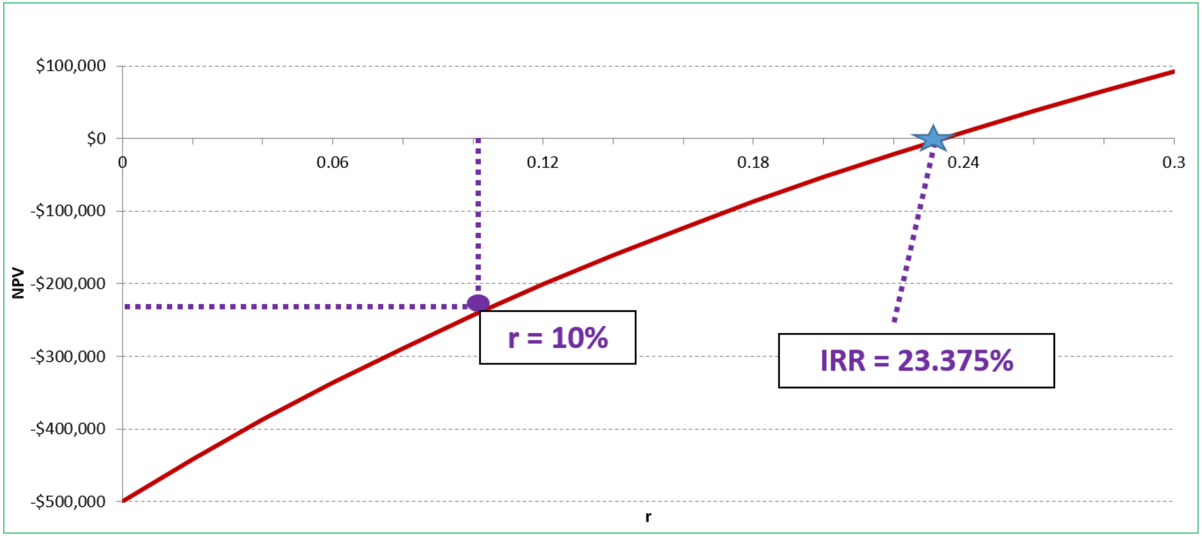
IRR: the graphing method

- Step 1: Plug in a range of *r* and calculate the respective NPVs
- Step 2: Connect the dots

Note: the x-intercept of the graph shows the *r* when NPV = 0, i.e. the IRR.



Prof. Riordan's Book Project



- Prof. Riordan's deal can be seen as a **financing** opportunity:
  - He *receives* cash at time 0 and *pays out* over three years
  - Cash inflows precedes cash outflows - Different from our previous examples.
- In the case of a **financing** oppotunity , the IRR decision rule "reverses"
  - if IRR < discount rate $\rightarrow$ Accept project
  - If IRR > discount rate $\rightarrow$ Reject project

IRR for **financing** type projects

- **Financing** type projects are those for which you get cash upfront which is positive followed by negative cash flows in the future.
- The decision rule for financing type projects is the opposite to that for investing/normal type projects:
  - Accept if IRR < required rate
  - Reject if IRR > required rate
- NPV decision rules are still the same.

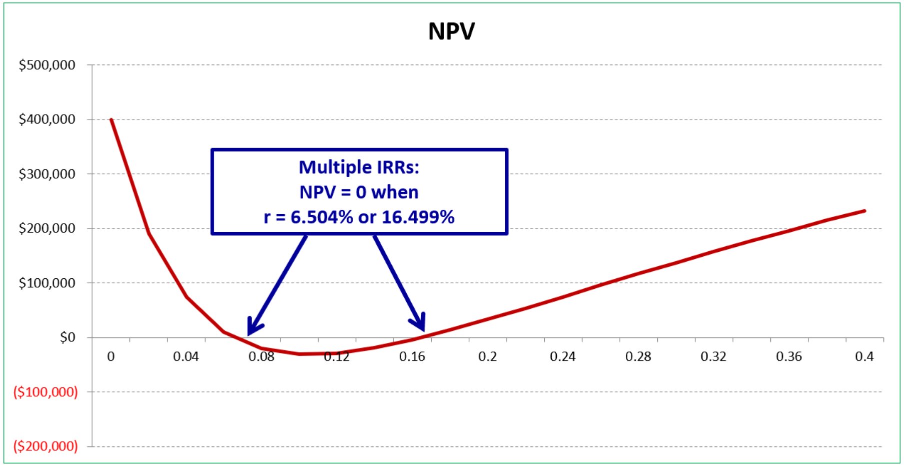
Multiple IRRs

Suppose Prof. Riordan's deal also includes royalty cash flows which are expected to be $30,000 per year for the next 30 years after the book is completed.

Now what should his decision be using the IRR rule?

What does the timeline look like?

Prof. Riordan's Book Project (with royalties)



- If cash flows "flip-flop", may obtain non-unique IRR values:
    - NPV > 0 if discount rate is *low* or *high*
    - NPV < 0 for *moderate* discount rates
- Why is this happening? Is this an investing or financing project? What should the IRR decision rule be?
- A simpler solution would be: **Just use the NPV decision rule.**

The Scale Problem

Suppose we can expand to either Houston or San Antonio:

Mutually Exclusive Projects					
Year	*0*	*1*		**IRR**	**NPV**
Houston	-$1,000	$2,500		**150%**	**$1,272.73**
San Antonio	-$10,000	$15,000		**50%**	**$3,636.36**

Discount rate	**10%**

We have a conflict. The IRR rule chooses the Houston project but San Antonio has a much higher NPV. Why is this happening?

Solutions to the **scale problem**:

- Just use NPV rule
- Incremental IRR

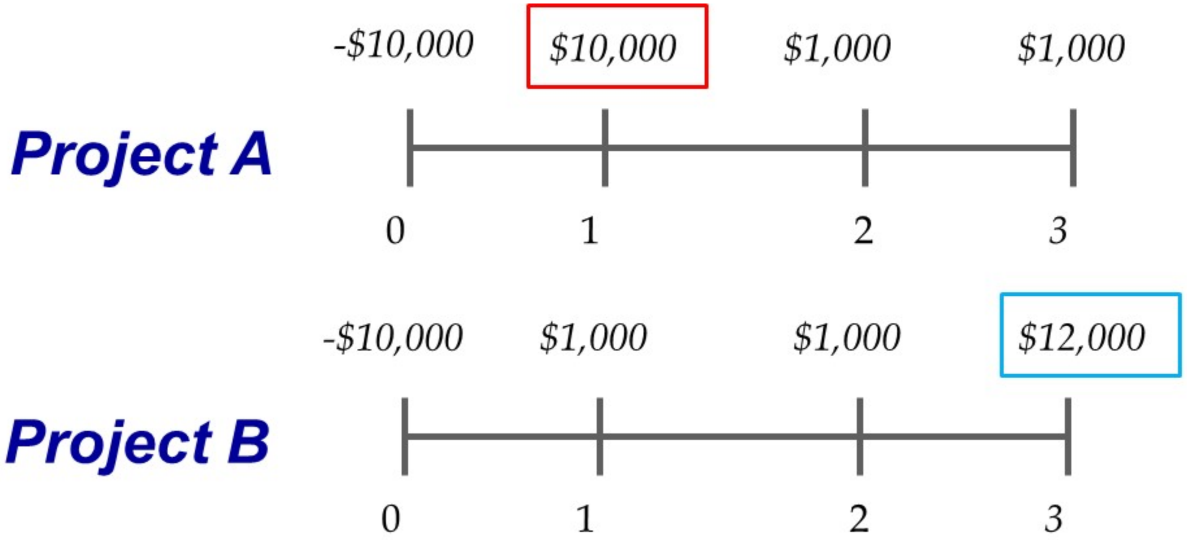
Incremental IRR

Do the difference between the two projects and calculate the IRR, then compare that IRR to the cost of capital.

	A	B	C	D	E	F	G	H
1								
2			*Mutually Exclusive Projects*					
3			*Year*	*0*	*1*		**IRR**	**NPV**
4			**Houston**	-$1,000	$2,500		**150%**	**$1,272.73**
5			**San Antonio**	-$10,000	$15,000		**50%**	**$3,636.36**
6								
7			**Discount rate**	**10%**				
8								
9								
10								
11			*Incremental IRR*					
12			*Year*	*0*	*1*		**IRR**	**NPV**
13			**Incremental CF(t)**	-$9,000	$12,500		**38.89%**	**$2,363.64**
14								
15			**Discount rate**	**10%**				
16								

What should be the decision based on incremental IRR?

The Timing Problem



- The preferred project in this case depends on the discount rate, not the IRR.
- Both projects have a large cash flow but time value of money will affect the final decision.

The Timing Problem

- The preferred project in this case depends on the discount rate, not the IRR.
- There is a point at which both projects have a negative NPV
- At lower discount rates, Project B is preferred to Project A
- At higher discount rates, Project A is preferred to Project B
- Where is the *crossover rate*?

I	J	K	L
	NPV(A)	NPV(B)	NPV(B-A)
0	$2,000.00	$4,000.00	$2,000.00
0.01	$1,851.88	$3,617.48	$1,765.60
0.02	$1,707.41	$3,249.43	$1,542.02
0.03	$1,566.48	$2,895.17	$1,328.69
0.04	$1,428.94	$2,554.05	$1,125.11
0.05	$1,294.68	$2,225.46	$930.79
0.06	$1,163.58	$1,908.82	$745.25
0.07	$1,035.53	$1,603.59	$568.06
0.08	$910.43	$1,309.25	$398.82
0.09	$788.18	$1,025.31	$237.14
0.1	$668.67	$751.31	$82.64
0.11	$551.82	$486.82	($65.00)
0.12	$437.55	$231.41	($206.13)
0.13	$325.75	($15.30)	($341.05)
0.14	$216.37	($253.68)	($470.05)
0.15	$109.31	($484.10)	($593.41)
0.16	$4.51	($706.88)	($711.39)
0.17	($98.11)	($922.34)	($824.23)
0.18	($198.61)	($1,130.79)	($932.18)
0.19	($297.06)	($1,332.51)	($1,035.45)
0.2	($393.52)	($1,527.78)	($1,134.26)

The Timing Problem: Incremental IRR

- To find the *crossover rate*, use incremental cash flows (blue row)
- Compute the IRR after taking the difference between Project B and Project A cash flows
- The crossover rate (IRR of B-A) ≈ 10.55%

Year	0	1	2	3
CF(A)	-$10,000	$10,000	$1,000	$1,000
CF(B)	-$10,000	$1,000	$1,000	$12,000
CF(B-A)	$0	-$9,000	$0	$11,000

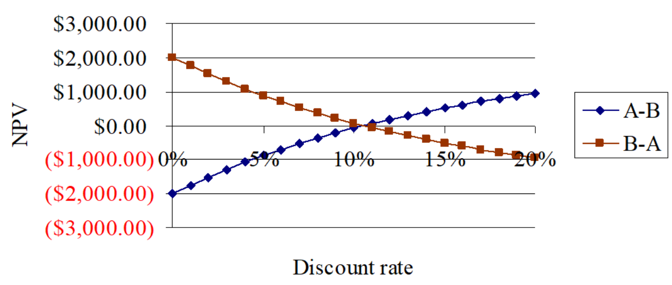
IRR(B-A)	10.55%
IRR(A)	16.04%
IRR(B)	12.94%

Calculating the Crossover Rate

- Should you compute the incremental IRR for (A-B) or (B-A)?

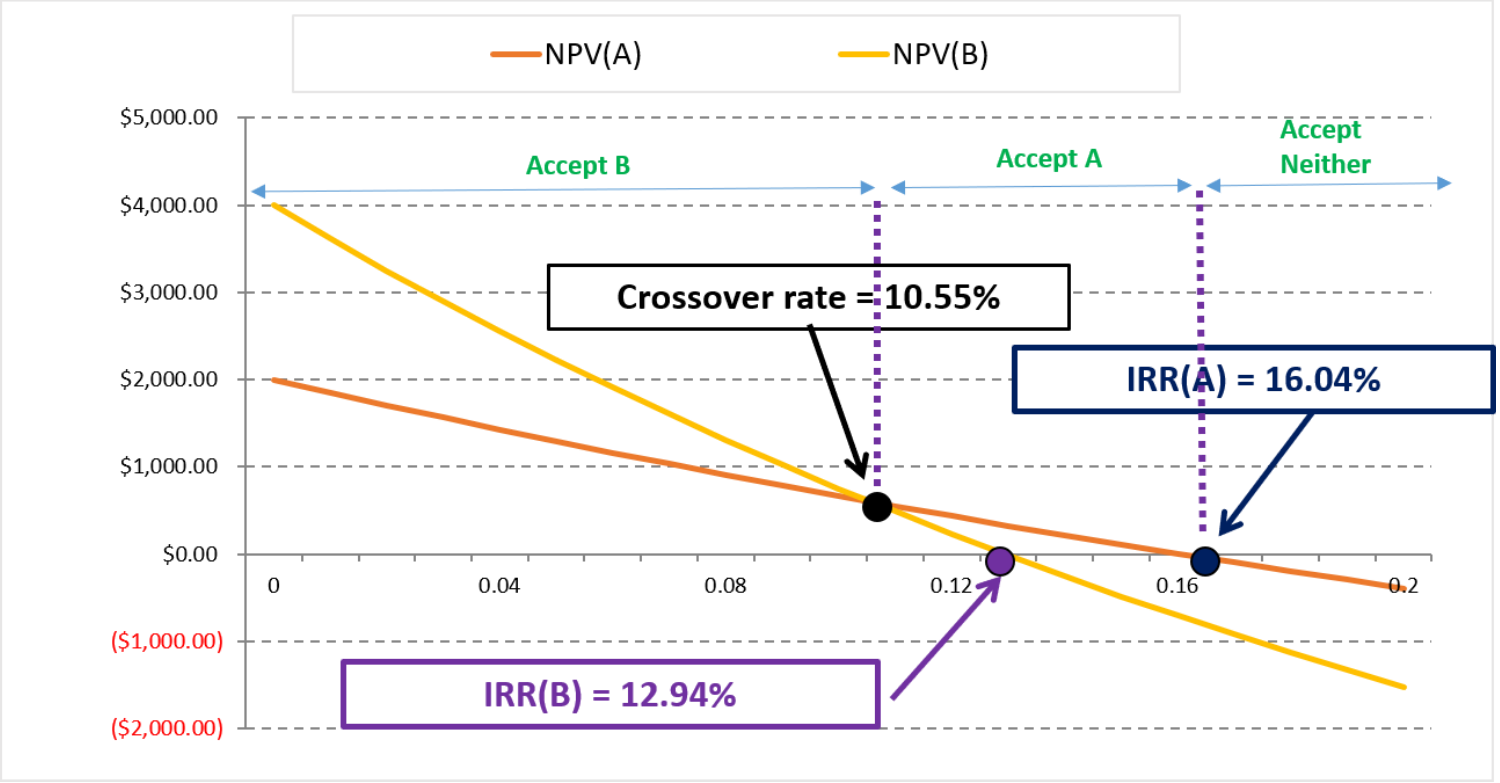
- The suggestion is to *perform the substraction so that the first nonzero cash flow is negative* (i.e. In this case, B-A)

- This makes the incremental project an "*investing* project" so that the ultimate decision is more intuitive (Choose B over A if IRR > r)



Year	Project A	Project B	Project A-B	Project B-A
0	($10,000)	($10,000)	$0	$0
1	$10,000	$1,000	$9,000	($9,000)
2	$1,000	$1,000	$0	$0
3	$1,000	$12,000	($11,000)	$11,000

Timing Problem: Graphical Solution



Payback Period (PP)

PP: Amount of time required for an investment to generate sufficient cash flows to recover its initial cost.

Payback Period decision rule:

- A project is accepted if its packback period is less than a specified cutoff period (usually 2-3 years).

Payback Period: an Example

Back to the New York and Chicago example. Using the payback period as decision criteria. Assume a payback period cutoff of 3 years.

Year	0	1	2	3	4
CF(t): New York	-1000	500	400	300	100
CF(t): Chicago	-1000	100	400	400	600
Discount Rate	0.10				
Remaining Balance (New York)	-1000	-500	-100	200	
Remaining Balance (Chicago)	-1000	-900	-500	-100	500
Payback Period (New York)	2.333				
Payback Period (Chicago)	3.167				

We would accept New York and reject Chicago.

Payback Period: Pros and Cons

Pros:

- Very simple to calculate and easy to understand
  - Useful for small day-to-day decisions
- May be useful for firms with limited access to capital
  - Focus on *quick cash recovery*

Cons:

- Timing of cash flows is ignored (recall that using the NPV method, the Chicago expansion was worth $131.82 and the New York expansion was only worth $78.82)
- Cash flows after the payback period are ignored
- Arbitrary benchmark: 2 years? 3 years? more/less?

Profitability Index (PI)

PI: Amount of dollars (in present value) generated per dollar investment.

$$PI = \frac{\sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}}{C_0}$$

Profitability Index investment rules:

- PI > 1 $\rightarrow$ Accept project
- PI < 1 $\rightarrow$ Reject project

Profitability Index: Pros and Cons

Pros: Capital Rationing

- Since firms may not have sufficient capital to fund all positive NPV projects.
- By ranking projects using PI and choosing the highest PI project(s), firms get the best "bang for buck" project.

Cons:

- Does not account for the scale of the project.
- Projects with lower PI may have higher NPV due to larger cash flow sizes but requires larger amount of initial investment.

What do CFOs use in practice?

A. Historical Comparison of the Primary Use of Various Capital Budgeting Techniques							
	1959	1964	1970	1975	1977	1979	1981
Payback period	34%	24%	12%	15%	9%	10%	5.0%
Average accounting return (AAR)	34	30	26	10	25	14	10.7
Internal rate of return (IRR)	19	38	57	37	54	60	65.3
Net present value (NPV)	—	—	—	26	10	14	16.5
IRR or NPV	19	38	57	63	64	74	81.8

B. Percentage of CFOs Who Always or Almost Always Used a Given Technique in 1999				
Capital Budgeting Technique	Percentage Always or Almost Always Using	Average Score [Scale is 4 (always) to 0 (never)]		
		Overall	Large Firms	Small Firms
Internal rate of return	76%	3.09	3.41	2.87
Net present value	75	3.08	3.42	2.83
Payback period	57	2.53	2.25	2.72
Discounted payback period	29	1.56	1.55	1.58
Accounting rate of return	20	1.34	1.25	1.41
Profitability index	12	.83	.75	.88

Sources: J.R. Graham and C.R. Harvey, "The Theory and Practice of Corporate Finance: Evidence from the Field," *Journal of Financial Economics*, May–June 2001, pp. 187–244; J.S. Moore and A.K. Reichert, "An Analysis of the Financial Management Techniques Currently Employed by Large U.S. Corporations," *Journal of Business Finance and Accounting*, Winter 1983, pp. 623–45; M.T. Stanley and S.R. Block, "A Survey of Multinational Capital Budgeting," *The Financial Review*, March 1984, pp. 36–51.

Formula Sheet

$$NPV = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} - C_0$$

$$ \sum{t=1}^T\frac{CF_t}{(1+IRR)^t} -C_0 = 0

PI = \frac{\sum{t=1}^T \frac{CF_t}{(1+r)^t}}{C_0} $$