Chapter 5

Net Present Value and Other Investment Rules

净现值和投资评价的其他方法

Personal Capital Budgeting Examples

- Go to college?
  - How expensive is college?
  - How long will it take?
  - How much more will I make with a college degree?
  - What are the opportunity costs of wages while in college?

College cash flows

- Average costs to attend a 4 year university in the U.S. have risen from about $7,000 in 1996 to about $12,000 in 2010.

- As of 2010, the average annual earnings for a high school graduate were $31,000. The average annual earnings for a college graduate were $51,000. For simplicity, let's ignore taxes and just assume these are all after-tax cash flows.

- Assume that you complete the degree in 4 years. You work for 50 years after attaining your degree. All cash flows occur at the end of the period (e.g. no outflows at t=0).

Key Concepts and Skills

- Be able to compute payback and discounted payback and understand their shortcomings
- Be able to compute the internal rate of return and profitability index, understanding the strengths and weaknesses of both approaches
- Be able to compute net present value and understand why it is the best decision criterion

Chapter Outline

Good Decision Criteria

- All cash flows considered?
- Time value of money considered?
- Risk-adjusted?
- Ability to rank projects?
- Indicates added value to the firm?

5.1 The Net Present Value (NPV) Rule 净现值

- Net Present Value (NPV) =

  Total PV of future CF's - Initial Investment
- Estimating NPV:
  1. Estimate future cash flows: how much? and when?
  2. Estimate discount rate
  3. Estimate initial costs
- Minimum Acceptance Criteria: Accept if NPV > 0
- Ranking Criteria: Choose the highest NPV

Net Present Value

Sum of the PVs of all cash flows

$$\mathbf{NPV} = \sum_{\mathbf{t = 0}}^{\mathbf{n}} \frac{\mathbf{CF_t}}{\mathbf{(1 + R)^t}}$$

NOTE: t=0

Initial cost often is CF_0 and is an outflow.

$$NPV = \sum_{t = 1}^{n} \frac{CF_t}{(1 + R)^t} - CF_0$$

Sample Project Data

- You are looking at a new project and have estimated the following cash flows, net income and book value data:
  - Year 0: CF = -165,000
  - Year 1: CF = 63,120 NI = 13,620
  - Year 2: CF = 70,800 NI = 3,300
  - Year 3: CF = 91,080 NI = 29,100
- Your required return for assets of this risk is 12%.

Computing NPV for the Project

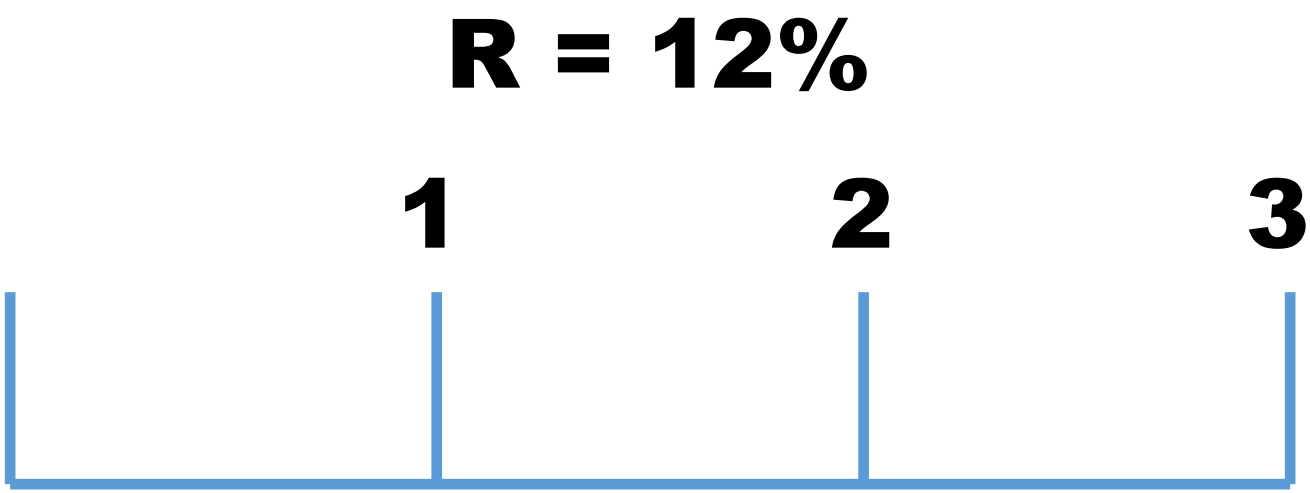
- Using the formula:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+R)^t}$$

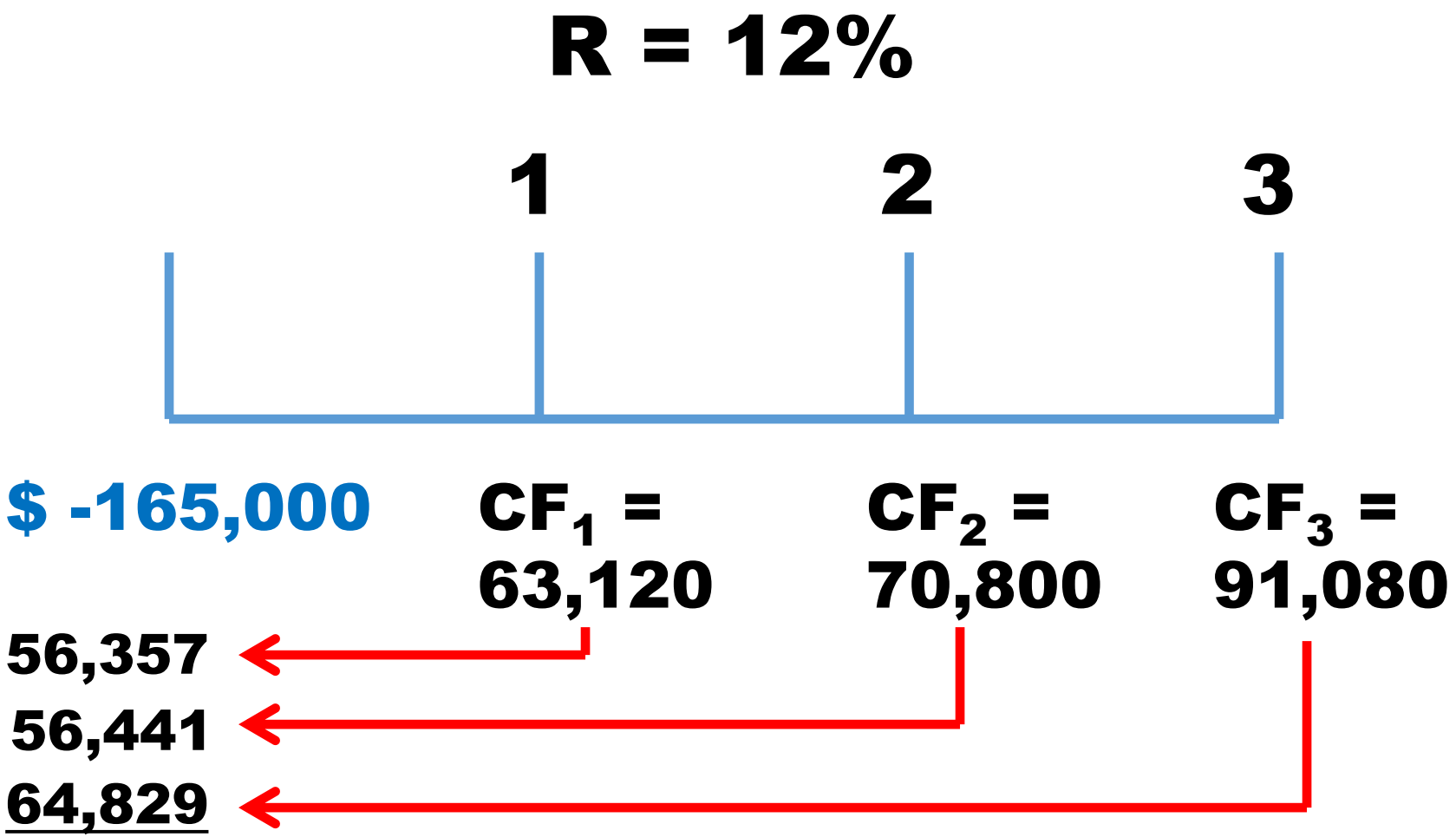
NPV = -165,000/(1.12)^0 + 63,120/(1.12)^1 + 70,800/(1.12)^2 + 91,080/(1.12)^3 = 12,627.41

Capital Budgeting Project			NPV
		Required Return =	12%
Year	CF	Formula	Disc CFs
0	(165,000.00)	=(-165000)/(1.12)^0 =	(165,000.00)
1	63,120.00	=(63120)/(1.12)^1 =	56,357.14
2	70,800.00	=(70800)/(1.12)^2 =	56,441.33
3	91,080.00	=(91080)/(1.12)^3 =	64,828.94
			12,627.41

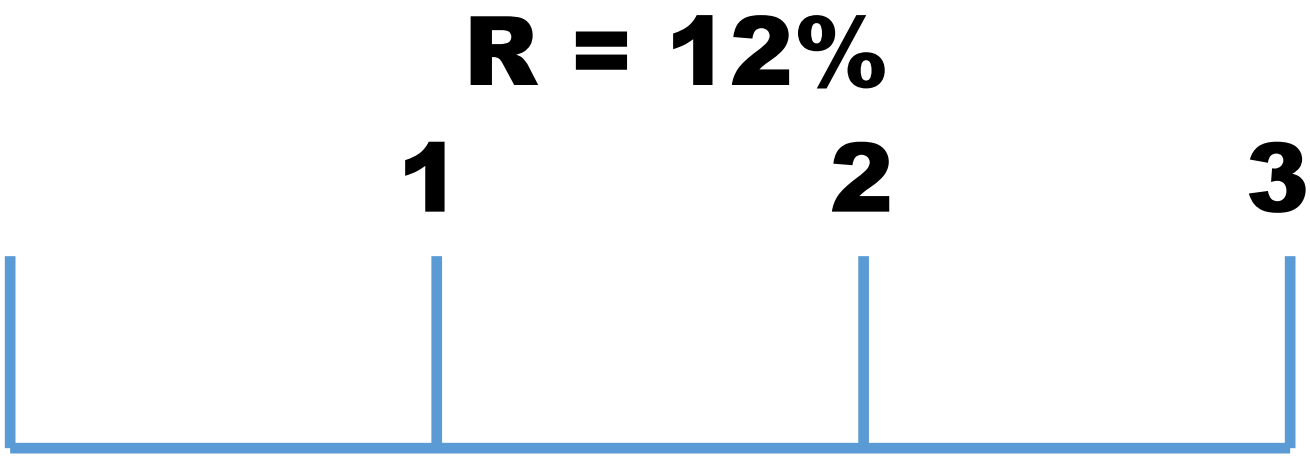
Computing NPV for the Project



Net Present Value Computation Step 1



Net Present Value Computation Step 2



$ -165,000 CF_1 = 63,120 CF_2 = 70,800 CF_3 = 91,080

NPV = PV of Inflows – PV of Outflows

NPV =$177,627 - $165,000 = $12,627

Why Use Net Present Value?

- Accepting positive NPV projects benefits shareholders.
  - ✓NPV uses cash flows
  - ✓NPV uses all the cash flows of the project
  - ✓NPV discounts the cash flows properly

5.2 The Payback Period Method 回收期法

- How long does it take the project to “pay back” its initial investment?
- Payback Period = number of years to recover initial costs
- Minimum Acceptance Criteria:
  - Set by management
- Ranking Criteria:
  - Set by management

Computing Payback for the Project

Capital Budgeting Project

Year	CF	Cum. CFs
0	$ (165,000)	$ (165,000)
1	$ 63,120	$ (101,880)
2	$ 70,800	$ (31,080)
3	$ 91,080	$ 60,000

Payback = year 2 +
+ (31080/91080)

Payback = 2.34 years

- ***Do we accept or reject the project?***

Payback Period

What is the payback?

Year	Cash Flow
0	-$62,000
1	16,500
2	23,800
3	27,100
4	23,300

Payback Period = 2 + (62000-16500-23800)/27100

= 2.80 years

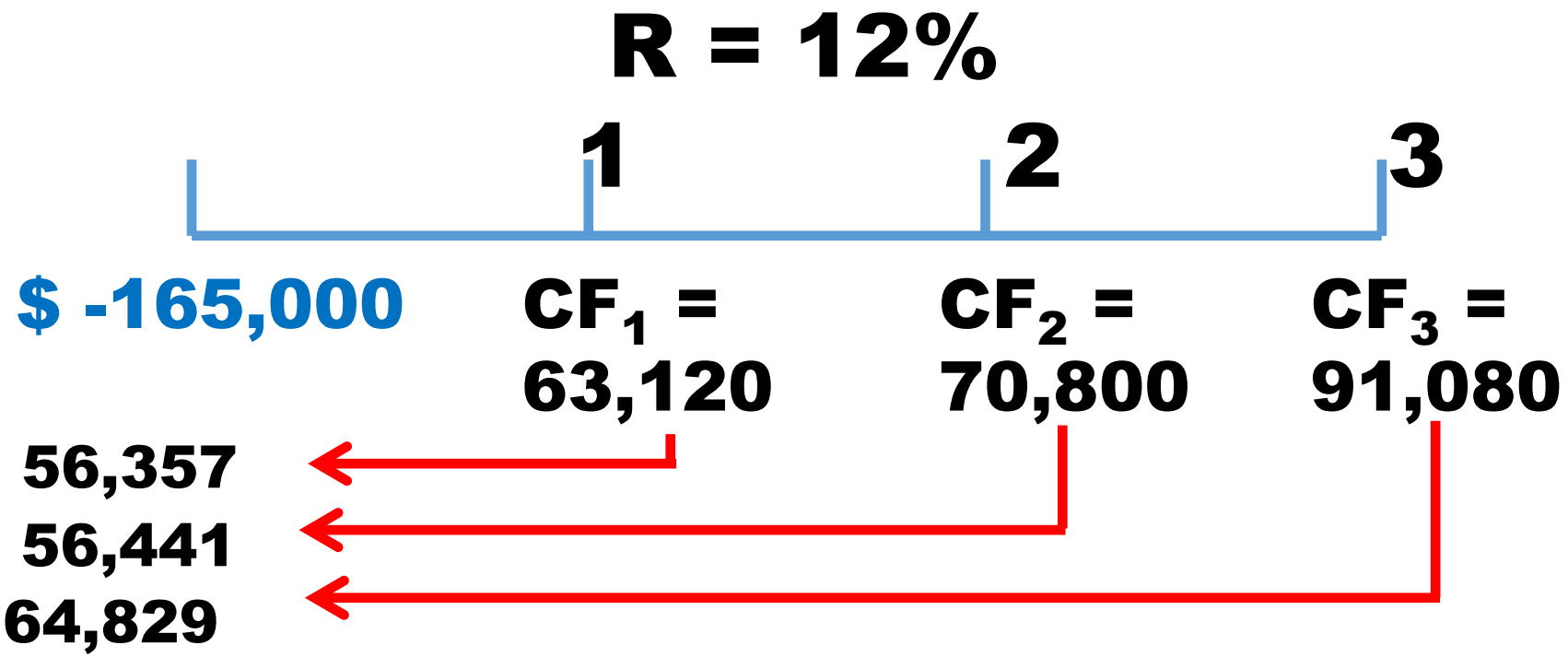
The Payback Period Method

- Disadvantages:
  - Ignores the time value of money
  - Ignores cash flows after the payback period
  - Biased against long-term projects
  - Requires an arbitrary acceptance criteria
  - A project accepted based on the payback criteria may not have a positive NPV
- Advantages:
  - Easy to understand
  - Biased toward liquidity

5.3 The Discounted Payback Period 折现回收期法

- How long does it take the project to “pay back” its initial investment, taking the time value of money into account?
- Under this approach, we first discount the cash flows. Then we ask how long it takes for the discounted cash flows to equal the initial investment.
- Decision rule: Accept the project if it pays back on a discounted basis within the specified time.
- By the time you have discounted the cash flows, you might as well calculate the NPV.

Discounted Payback Computation



Discount payback period = 2 + (165000-56357-56441)/64829
= 2.81

5.4 The Internal Rate of Return 内部收益率

- IRR: the discount rate that sets NPV to zero
- The number is internal to the project and does not depend on anything except the cash flows of the project.

- Minimum Acceptance Criteria:
  - Accept if the IRR exceeds the required return
  - The firm should be equally willing to accept or reject the project if the discount rate equals to IRR. The firm should accept the project if the discount rate is below IRR. The firm should reject the project if the discount rate is above IRR.

- Ranking Criteria:
  - Select alternative with the highest IRR

NPV vs. IRR

NPV: Enter R, solve for NPV

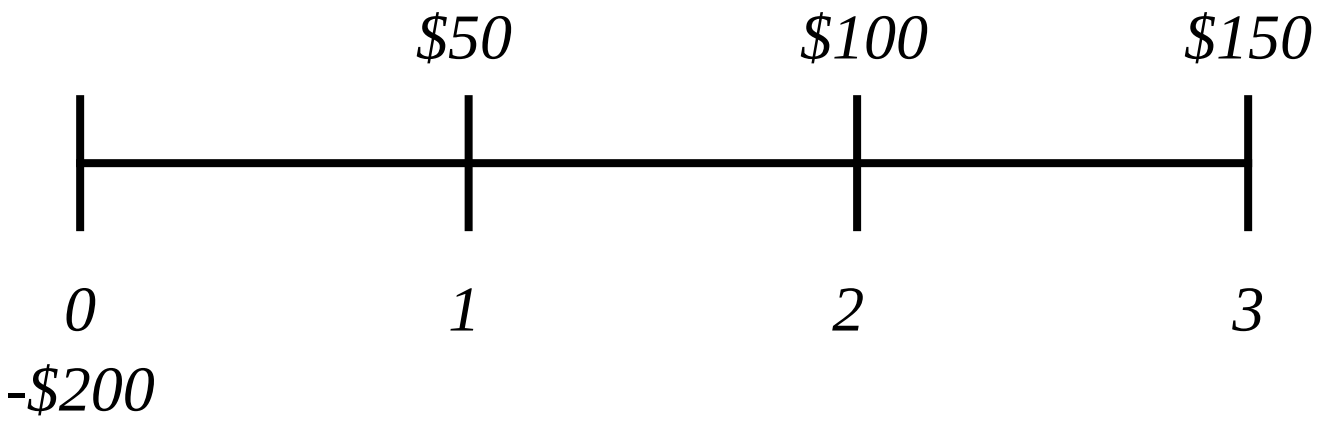
$$\sum_{t=0}^{n} \frac{CF_t}{(1+R)^t} = NPV$$

IRR: Enter NPV = 0, solve for IRR.

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

IRR: Example

Consider the following project:



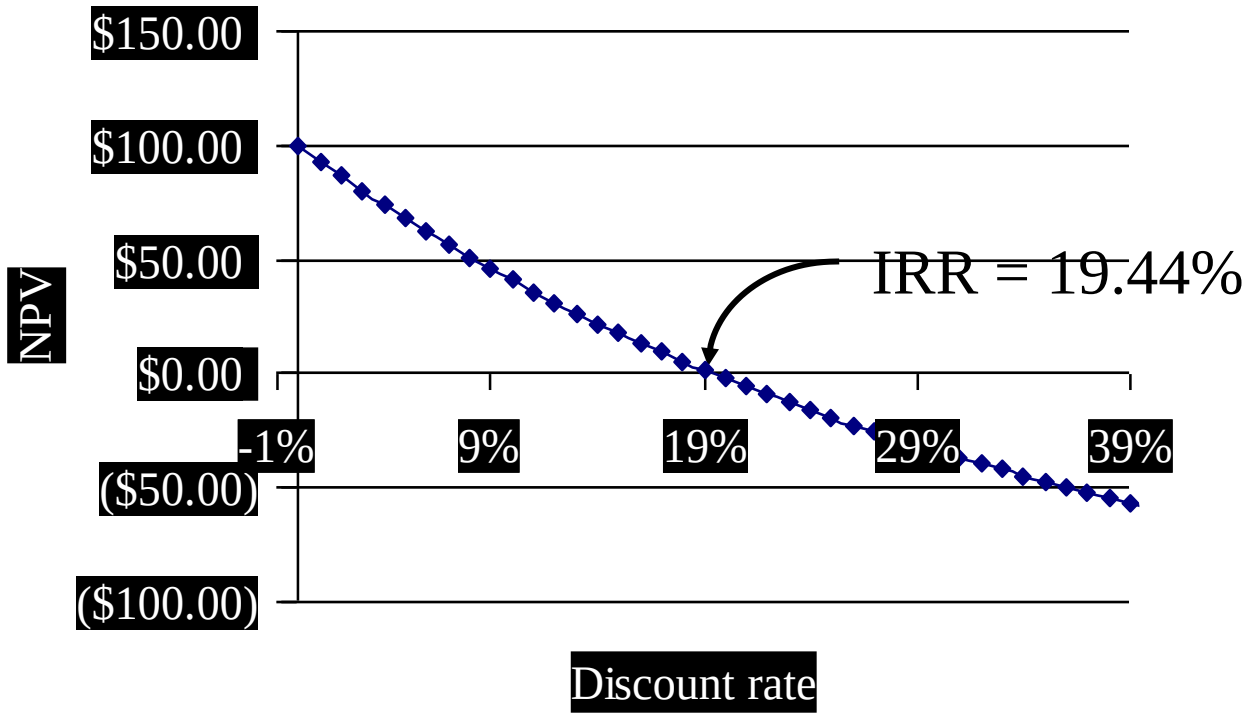
The internal rate of return for this project is 19.44%

$$NPV = 0 = -200 + \frac{\$50}{(1+IRR)} + \frac{\$100}{(1+IRR)^2} + \frac{\$150}{(1+IRR)^3}$$

NPV Payoff Profile

If we graph NPV versus the discount rate, we can see the IRR as the x-axis intercept.

0%	$100.00
4%	$73.88
8%	$51.11
12%	$31.13
16%	$13.52
20%	($2.08)
24%	($15.97)
28%	($28.38)
32%	($39.51)
36%	($49.54)
40%	($58.60)
44%	($66.82)



Internal Rate of Return (IRR)

- Disadvantages:
  - Does not distinguish between investing and borrowing
  - IRR may not exist, or there may be multiple IRRs
  - Problems with mutually exclusive investments

- Advantages:
  - Easy to understand and communicate

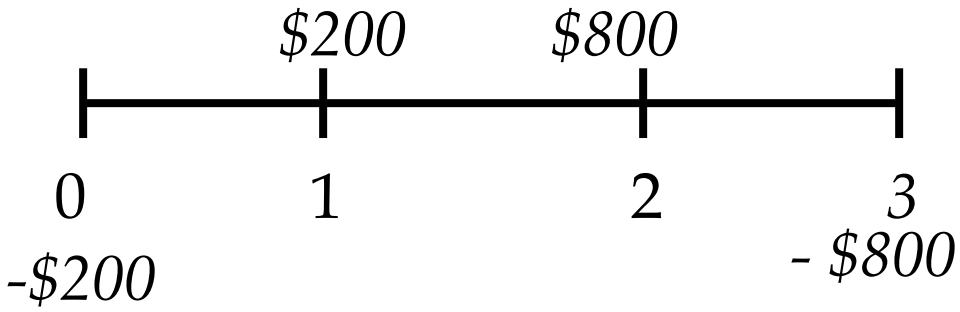
Mutually Exclusive vs. Independent 独立项目与互斥项目

- Mutually Exclusive Projects: only ONE of several potential projects can be chosen
  - RANK all alternatives, and select the best one.

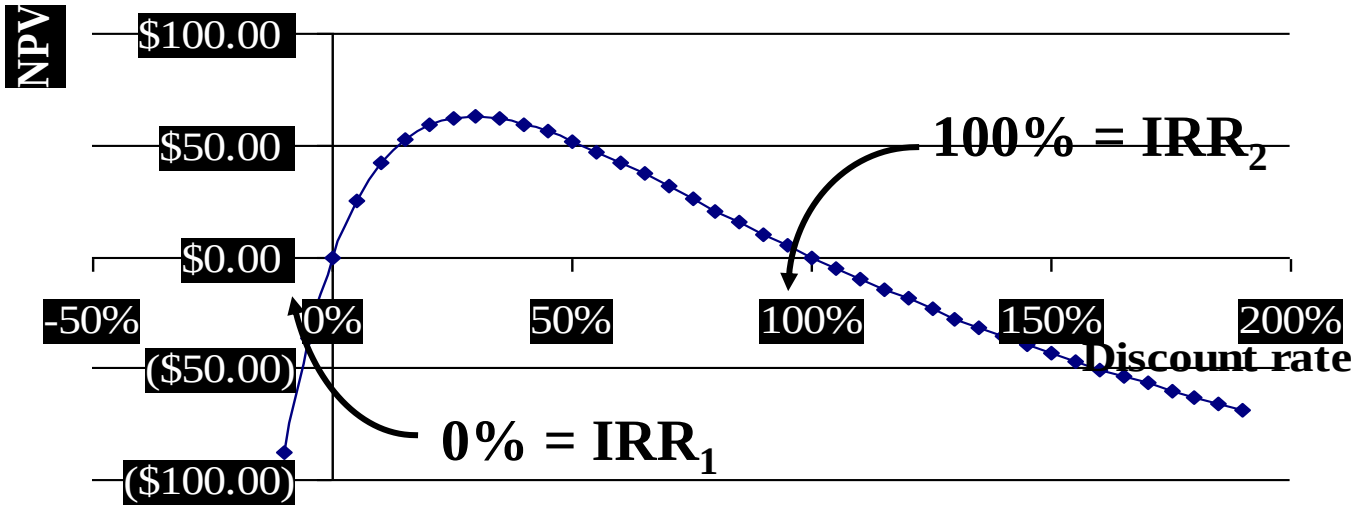
- Independent Projects: accepting or rejecting one project does not affect the decision of the other projects.
  - Must exceed a MINIMUM acceptance criteria

Multiple IRRs

There are two IRRs for this project:



Which one should we use?



IRR & Non-Conventional Cash Flows

- “Non-conventional” 非常规现金流量
  - Cash flows change sign more than once
  - Most common:
    - Initial cost (negative CF)
    - A stream of positive CFs
    - Negative cash flow to close project.
    - For example, nuclear power plant
  - More than one IRR ….
  - Which one do you use to make your decision?

Non-Conventional Cash Flows

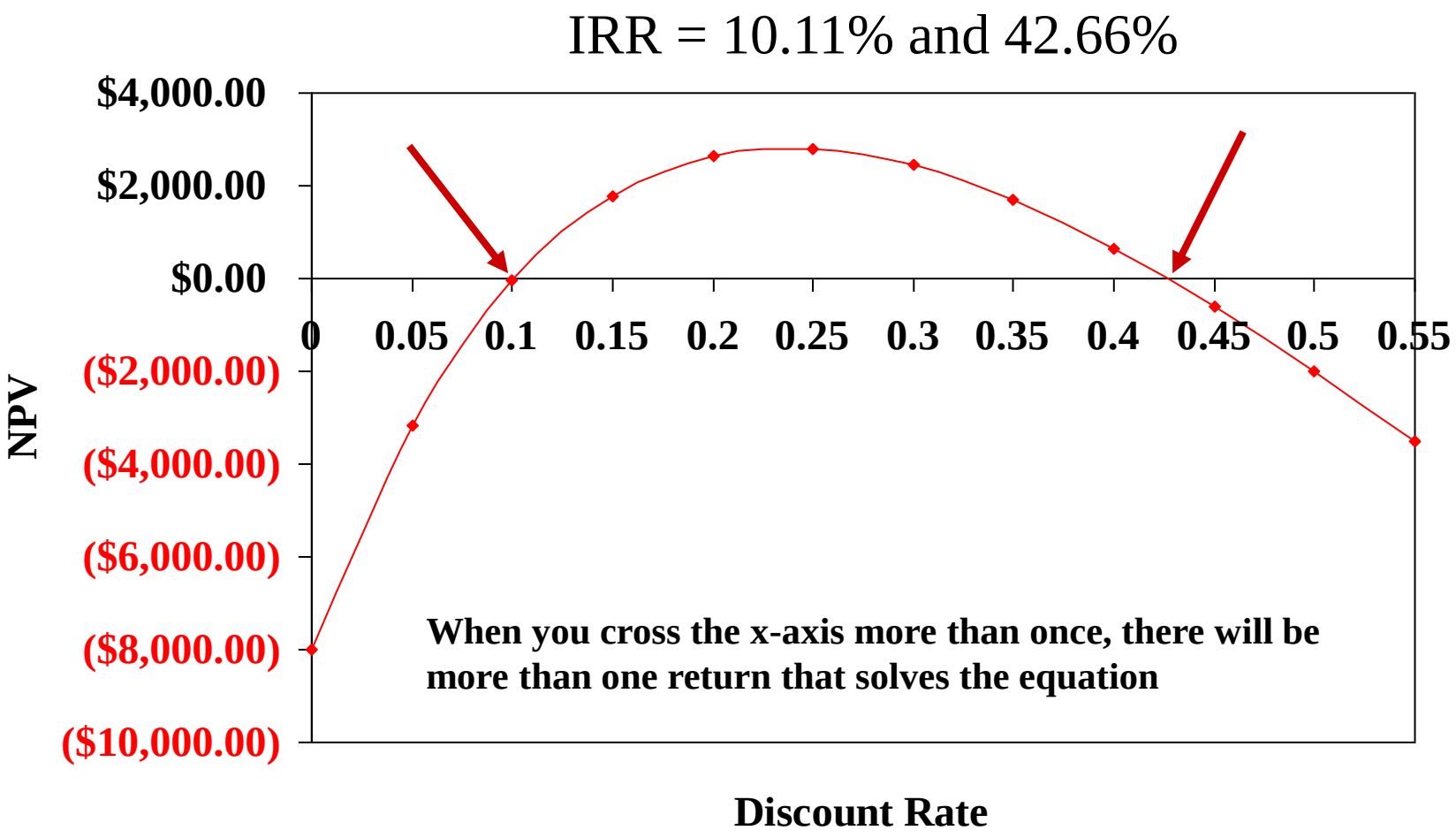
- Suppose an investment will cost $90,000 initially and will generate the following cash flows:
  - Year 1: 132,000
  - Year 2: 100,000
  - Year 3: -150,000
- The required return is 15%.
- Should we accept or reject the project?

Non-Conventional Cash Flows Summary of Decision Rules

- NPV > 0 at 15% required return, so you should ***Accept***
- IRR =10.11% (using a financial calculator), which would tell you to ***Reject***
- Recognize the non-conventional cash flows and look at the NPV profile

I =	15%	
YR	CF	
0	-$90,000	
1	$132,000	
2	$100,000	
3	-$150,000	
NPV	$1,769.54	> 0
IRR-1	10.11%	< 15%
IRR-2	42.66%	> 15%

NPV Profile


IRR = 10.11% and 42.66%
$4,000.00
$2,000.00
$0.00
($2,000.00)
($4,000.00)
($6,000.00)
($8,000.00)
($10,000.00)
NPV
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
When you cross the x-axis more than once, there will be more than one return that solves the equation
Discount Rate

Modified IRR 修正内部收益率

- Discounting and combining the later cash flows until only one change of sign remains.
- CF0 = -100; CF1 = 230; CF2 = -132; Require return = 14%
- With a discount rate of 14%, the value of the last cash flow, -$132, at the end of year 1 is:

  -$132/(1+0.14) = -$115.79

  The “adjusted total” cash flow at the end of year 1 is 114.21 (=230-115.79)
- The IRR rule now can be applied to the following cash flows

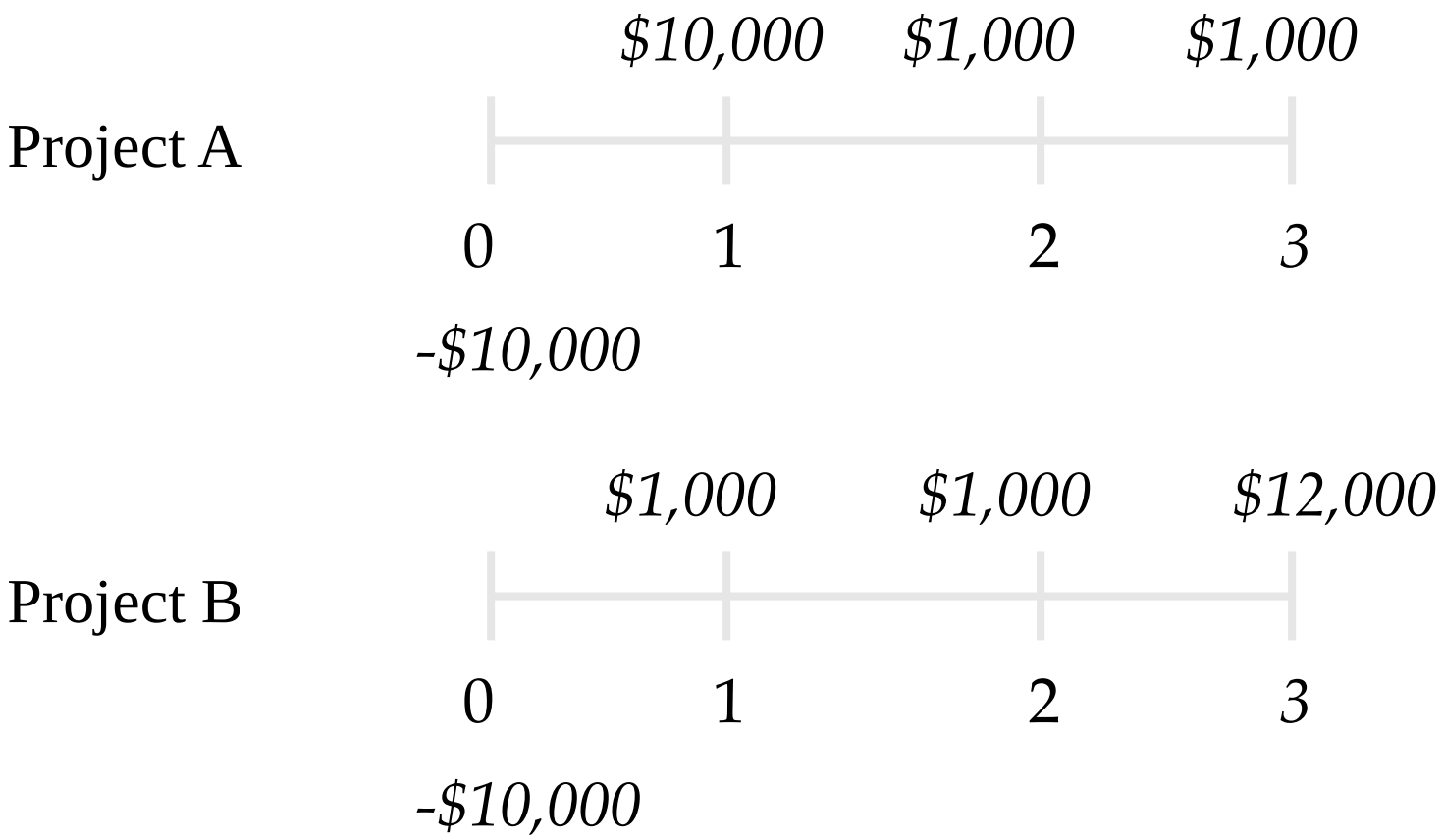
  CF0 = -100; CF1 = 114.21

The Scale Problem - Mutually Exclusive Projects
互斥项目所特有的问题 – 规模问题

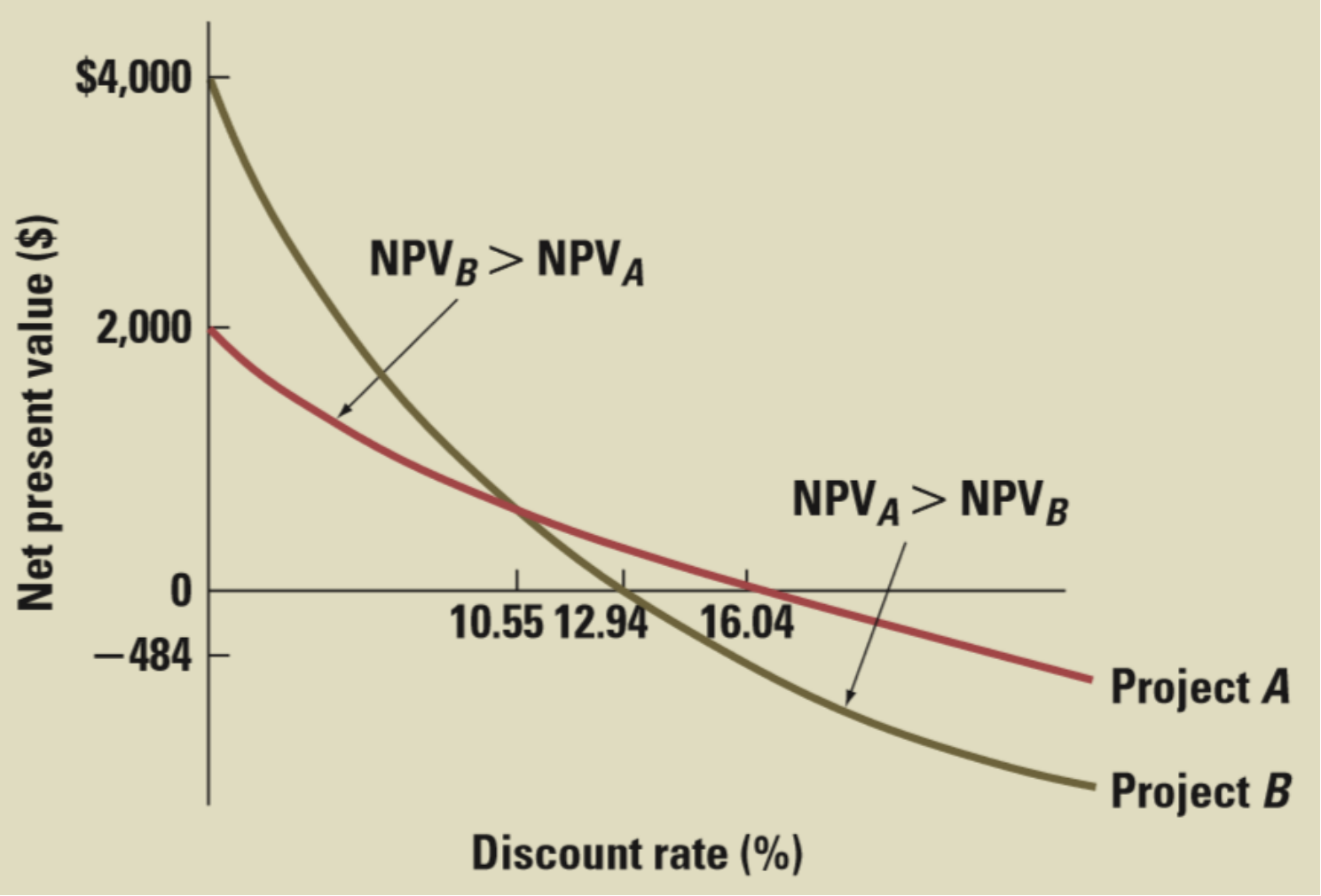
Would you rather make 100% or 50% on your investments?

What if the 100% return is on a $1 investment, while the 50% return is on a $1,000 investment?

The Timing Problem - Mutually Exclusive Projects
互斥项目所特有的问题 – 时间序列问题

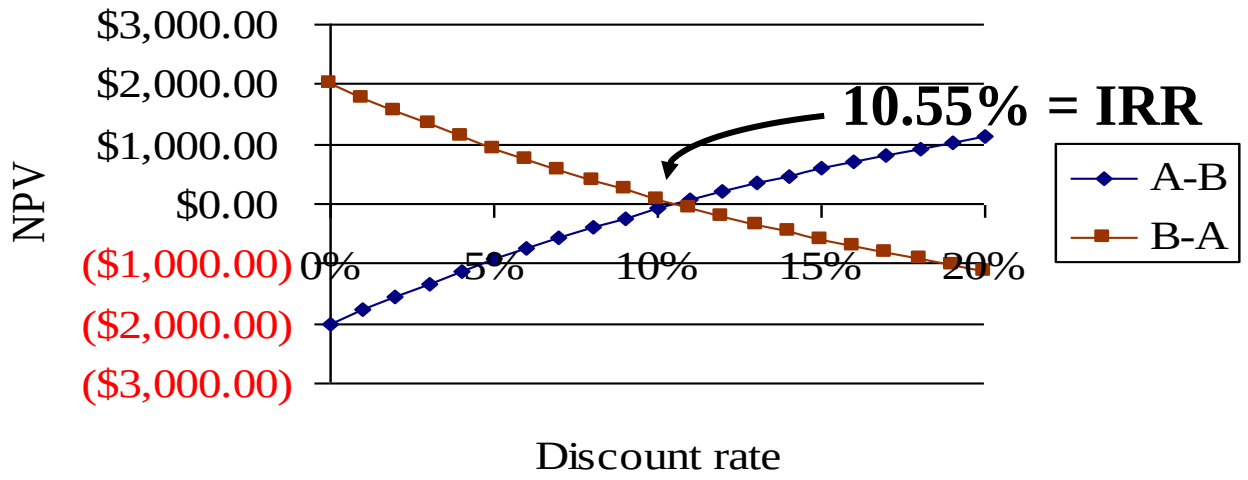


The Timing Problem



Calculating the Crossover Rate

Compute the IRR for either project “A-B” or “B-A”



NPV versus IRR

- NPV and IRR will generally give the same decision.
- Exceptions:
  - Non-conventional cash flows – cash flow signs change more than once
  - Mutually exclusive projects
    - Initial investments are substantially different
    - Timing of cash flows is substantially different

5.6 The Profitability Index (PI) 盈利指数法

$$PI = \frac{\text{Total PV of Future Cash Flows}}{\text{Initial Investent}}$$

- Minimum Acceptance Criteria:
  - Accept if PI > 1

- Ranking Criteria:
  - Select alternative with highest PI

Profitability Index Example

Year 0: CF = -165,000
Year 1: CF = 63,120
Year 2: CF = 70,800
Year 3: CF = 91,080

PI = PV of Inflows / PV of Outflows

$177,627 / $165,000 = 1.0765

A Profitability Index of 1.076 implies that for every $1 of investment, we create an additional $0.0765 in value. A PI >1 means the firm is increasing in value.

The Profitability Index

- Disadvantages:
  - Problems with mutually exclusive investments
- Advantages:
  - Easy to understand and communicate
  - Correct decision when evaluating independent projects

5.7 The Practice of Capital Budgeting

- The most frequently used technique for large corporations is either IRR or NPV.

	% Always or Almost Always
Internal rate of return (IRR)	75.6%
Net present value (NPV)	74.9
Payback method	56.7
Discounted payback	29.5
Profitability index	11.9

SOURCE: Figure 2 from John R. Graham and Campbell R. Harvey, "The Theory and Practice of Corporate Finance: Evidence from the Field," *Journal of Financial Economics* 60 (2001). Based on a survey of 392 CFOs.

Example of Investment Rules

Compute the IRR, NPV, PI, and payback period for the following two projects. Assume the required return is 10%.

Year	Project A	Project B
0	-$200	-$150
1	$200	$50
2	$800	$100
3	-$800	$150

Example of Investment Rules

	Project A	Project B
CF_0	-$200.00	-$150.00
PV_0 of CF_{1-3}	$241.92	$240.80
NPV =	$41.92	$90.80
IRR =	0%, 100%	36.19%
PI =	1.2096	1.6053

Example of Investment Rules

Payback Period:

	Project A		***Project B***	
Time	CF	Cum. CF	CF	Cum. CF
0	-200	-200	-150	-150
1	200	0	50	-100
2	800	800	100	0
3	-800	0	150	150

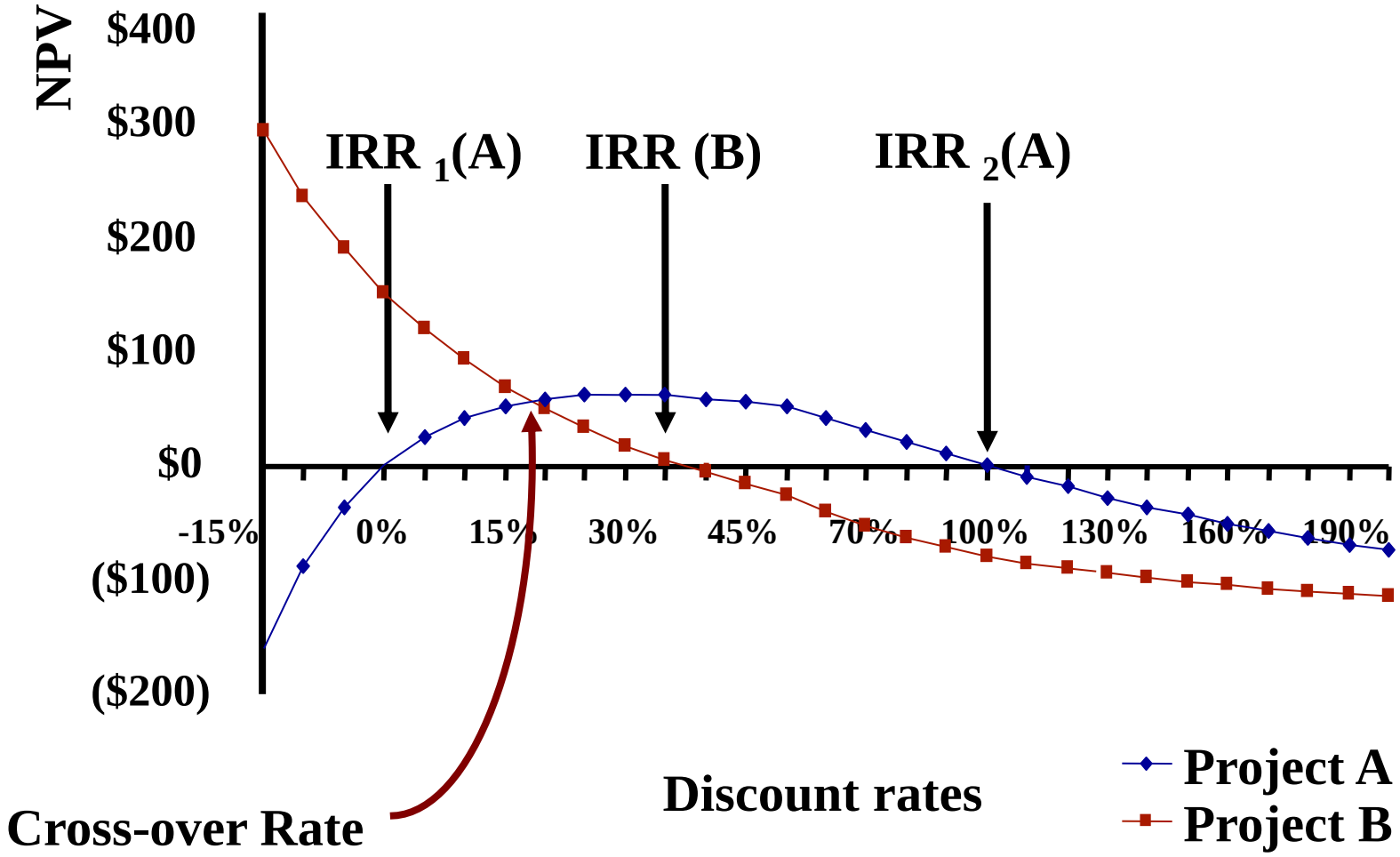
Payback period for project B = 2 years.

Payback period for project A = 1 or 3 years?

NPV and IRR Relationship

Discount rate	NPV for A	NPV for B
-10%	-87.52	234.77
0%	0.00	150.00
20%	59.26	47.92
40%	59.48	-8.60
60%	42.19	-43.07
80%	20.85	-65.64
100%	0.00	-81.25
120%	-18.93	-92.52

NPV Profiles



Summary – Discounted Cash Flow

- Net present value
  - Difference between market value and cost
  - Accept the project if the NPV is positive
  - Has no serious problems
  - Preferred decision criterion
- Internal rate of return
  - Discount rate that makes NPV = 0
  - Take the project if the IRR is greater than the required return
  - Same decision as NPV with conventional cash flows
  - IRR is unreliable with non-conventional cash flows or mutually exclusive projects
- Profitability Index
  - Benefit-cost ratio
  - Take investment if PI > 1
  - Cannot be used to rank mutually exclusive projects
  - May be used to rank projects in the presence of capital rationing

Summary – Payback Criteria

- Payback period
  - Length of time until initial investment is recovered
  - Take the project if it pays back in some specified period
  - Does not account for time value of money, and there is an arbitrary cutoff period
- Discounted payback period
  - Length of time until initial investment is recovered on a discounted basis
  - Take the project if it pays back in some specified period
  - There is an arbitrary cutoff period

Quick Quiz

- Consider an investment that costs $100,000 and has a cash inflow of $25,000 every year for 5 years. The required return is 9%, and payback cutoff is 4 years.
  - What is the payback period?
  - What is the discounted payback period?
  - What is the NPV?
  - What is the IRR?
  - Should we accept the project?
- What method should be the primary decision rule?
- When is the IRR rule unreliable?