Return on Investment

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Last Time

Discounted Cash Flow (DCF)

- Decision making
- Free cash flow
- Forecast drivers
- Forecasting free cash flow
- Sensitivity analysis
- Decision criteria

This Time

Return on investment

- IRR versus NPV

IRR

RECALL…

The internal rate of return of an asset is the one discount rate such that the NPV of the asset's free cash flows equals zero.

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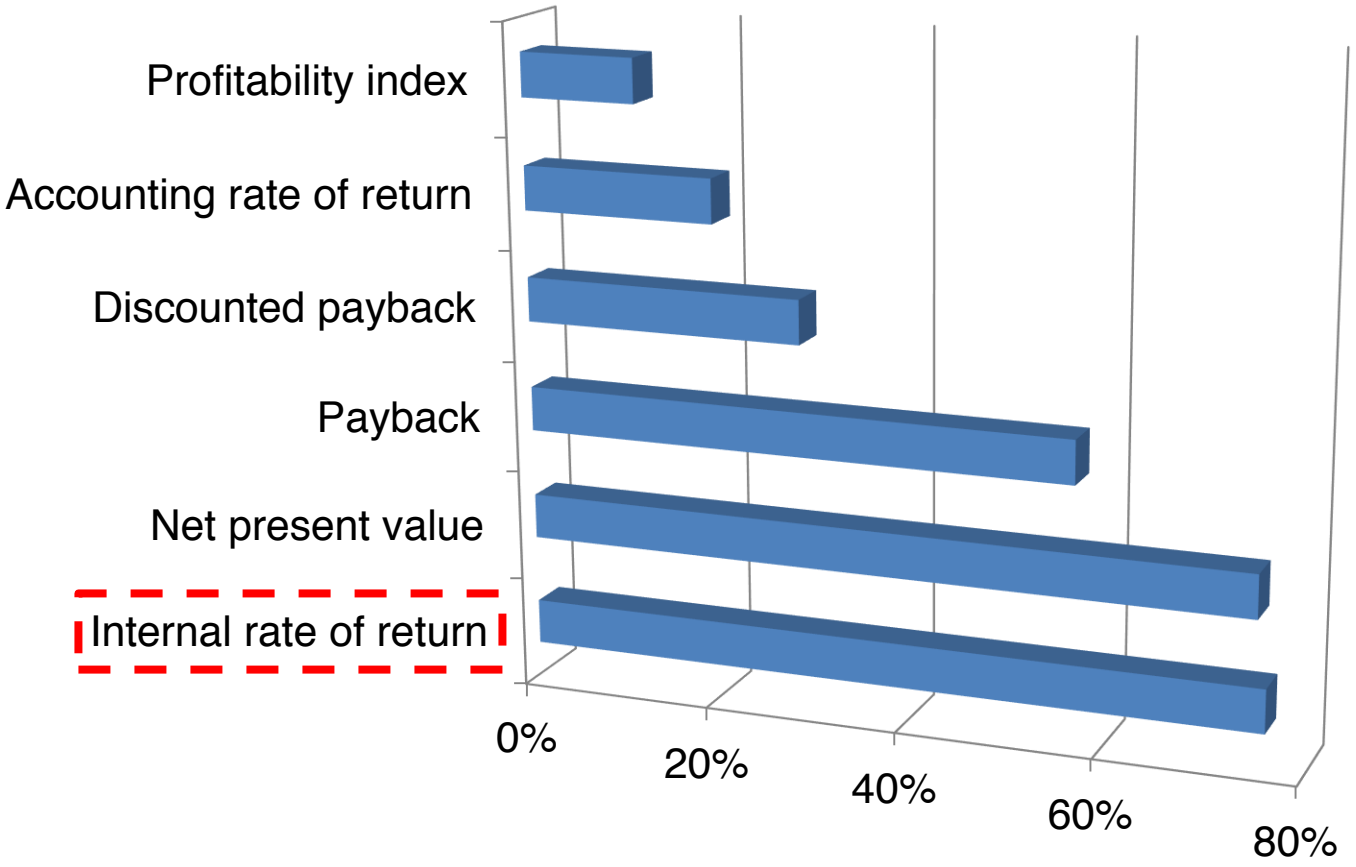
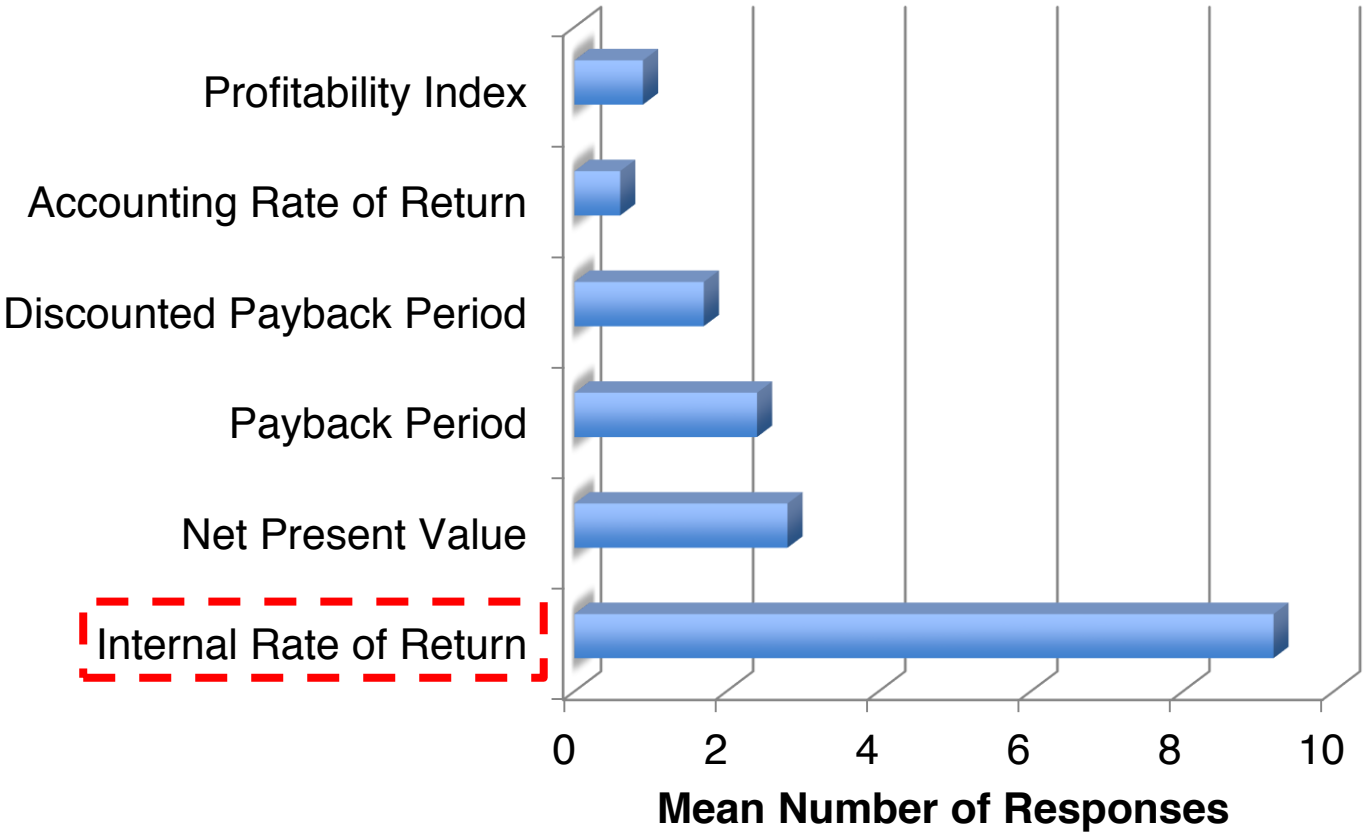
$$NPV = \frac{CF_1}{(1+IRR)} + \frac{CF_2}{(1+IRR)^2} + \frac{CF_3}{(1+IRR)^3} + \ldots + \frac{CF_T}{(1+IRR)^T} = 0$$

The IRR Decision Rule says accept all projects whose $IRR > R$, reject all projects whose $IRR < R$ where R is the hurdle rate

Rates of return are popular measures used for making decisions



Graham and Harvey, 2001, The theory and practice of corporate finance: Evidence from the field, *Journal of Financial Economics*



What do Private Equity Firms Say they Do? (Paul Gompers, Steve Kaplan, and Vladimir Mukharlyamov)

IRR V NPV

Lesson: The IRR rule leads to the same decisions – accept or reject – as the NPV rule if all negative cash flows precede all positive cash flows

Examples of CF sequences where IRR and NPV rules will coincide:

-, +, +, +, +

-, -, -, +, +, +, +, +, +

-, -, -, -, - , +

Examples of CF sequences where IRR and NPV rules may not coincide:

-, +, -, +, -, +

+, +, +, +, +, +, -, -, -, -

-, +, +, +, +, -

Can we compare projects using IRR?

Comparing Projects

Wharton wants to upgrade IT system and overhaul network infrastructure

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Puts out request for proposals (RFP)

Bid #1 from Cisco

Generate $60 million in cost savings over three years for up front cost of $100 million

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If Wharton's cost of capital is 12%, what is your assessment of this bid?

Bid #1 from Cisco

Generate $60 million in cost savings over three years for up front cost of $100 million

Cash flows first:

	Year			
	0	1	2	3
Bid #1: Cisco	-100	60	60	60

Bid #1 from Cisco

Generate $60 million in cost savings over three years for up front cost of $100 million

	Year				
	0	1	2	3	IRR
Bid #1: Cisco	-100	60	60	60	36%

$$0 = -100 + \frac{60}{(1+IRR)} + \frac{60}{(1+IRR)^2} + \frac{60}{(1+IRR)^3}$$

Bid #1 from Cisco

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IRR > *R* **and** CFs signs proper → Looks good!

Bid #1 from Cisco

Generate $60 million in cost savings over three years for up front cost of $100 million

	Year					
	0	1	2	3	IRR	NPV
Bid #1: Cisco	-100	60	60	60	36%	44.11

$$NPV = -100 + \frac{60}{(1+0.12)} + \frac{60}{(1+0.12)^2} + \frac{60}{(1+0.12)^3}$$

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NVP > 0 → Looks good!

Bid #1a from Cisco

Same cost savings ($60 mil over three years) but costs spread over time: $20 mil today, $35 mil over three years

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Bid #1a: Cisco (Costs)	-20	-35	-35	-35
Bid #1a: Cisco (Savings)	0	60	60	60
Bid #1a: Cisco (Net)	-20	25	25	25

Bid #1a from Cisco

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Bid #1a: Cisco (Net)	-20	25	25	25	112%

$$0 = -20 + \frac{25}{(1+IRR)} + \frac{25}{(1+IRR)^2} + \frac{25}{(1+IRR)^3}$$

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Bid #1a IRR (112%) > Bid #1 IRR (36%)

Bid #1a from Cisco

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Bid #1a: Cisco (Savings)	0	60	60	60		
Bid #1a: Cisco (Net)	-20	25	25	25	112%	40.05

$$NPV = -20 + \frac{25}{(1+0.12)} + \frac{25}{(1+0.12)^2} + \frac{25}{(1+0.12)^3}$$

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Bid #1a: Cisco (Net)	-20	25	25	25	112%	40.05

Bid #1 NPV ($44.11) > Bid #1a NPV ($40.05)

What is going on?

NPV → Bid #1 is better

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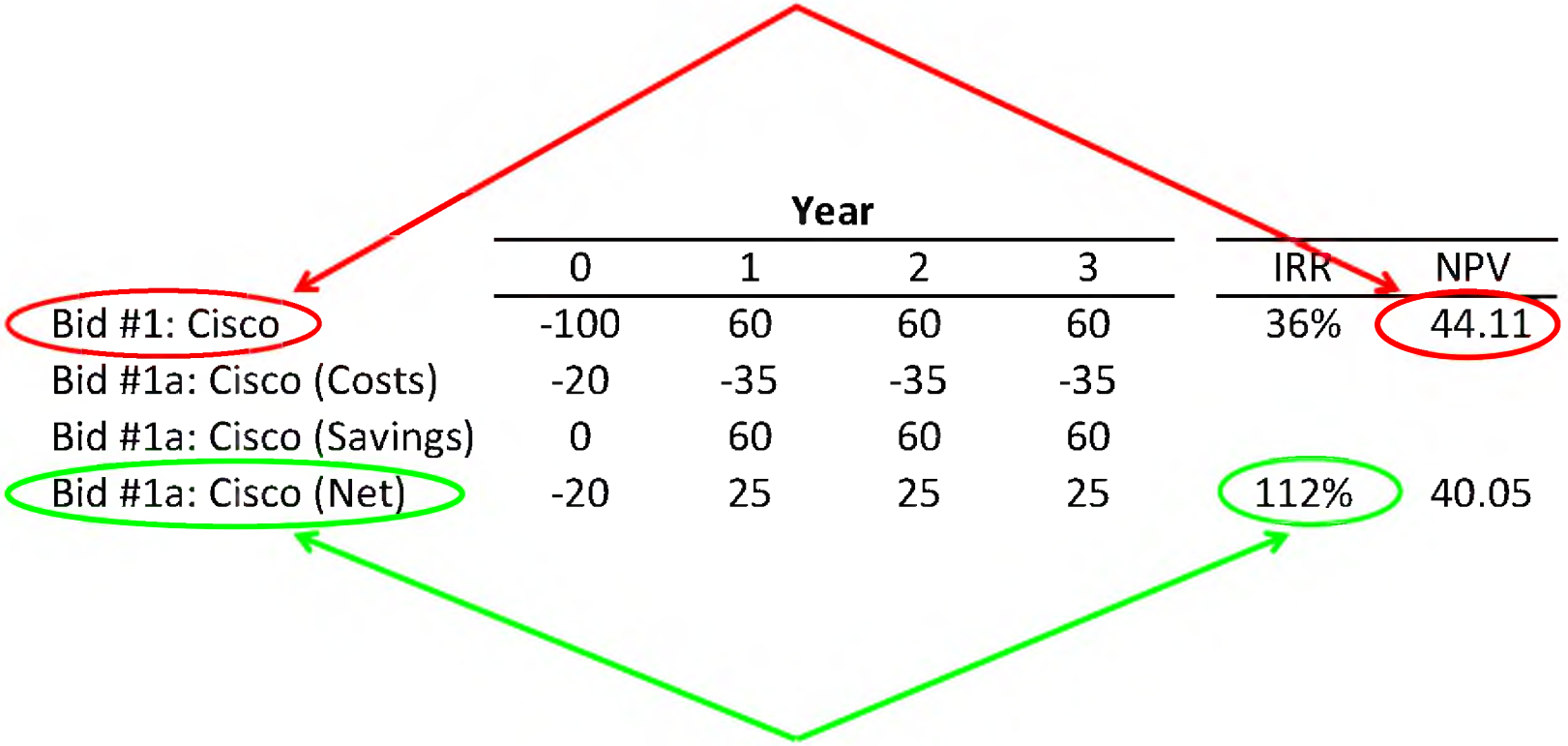

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IRR → Bid #1a is better

A closer look

	Year			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
Bid #1a: Cisco (Costs)	-20	-35	-35	-35

A closer look

	Year			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
Bid #1a: Cisco (Costs)	-20	-35	-35	-35
Bid #1a: Cisco (Implicit Loan)	80	-35	-35	-35

Bid 1a incorporates a loan from Cisco

A closer look

	Year			
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Bid 1a incorporates a loan from Cisco
What is the interest rate?

A closer look

	Year			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
Bid #1a: Cisco (Costs)	-20	-35	-35	-35
Bid #1a: Cisco (Implicit Loan)	80	-35	-35	-35

$$80 = \frac{35}{(1+R)} + \frac{35}{(1+R)^2} + \frac{35}{(1+R)^3} \Rightarrow R = 15\%$$

A closer look

	Year			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
Bid #1a: Cisco (Costs)	-20	-35	-35	-35
Bid #1a: Cisco (Implicit Loan)	80	-35	-35	-35

$$0 = -80 + \frac{35}{(1+IRR)} + \frac{35}{(1+IRR)^2} + \frac{35}{(1+IRR)^3} \Rightarrow IRR = 15\%$$

Note: This is also the IRR of the loan

A closer look

	Year			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
Bid #1a: Cisco (Costs)	-20	-35	-35	-35
Bid #1a: Cisco (Implicit Loan)	80	-35	-35	-35

$$80 = \frac{35}{(1+YTM)} + \frac{35}{(1+YTM)^2} + \frac{35}{(1+YTM)^3} \Rightarrow YTM = 15\%$$

Note: This is also the Yield-to-Maturity of the loan

A closer look

	Year			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
Bid #1a: Cisco (Costs)	-20	-35	-35	-35
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$$80 = \frac{35}{(1+YTM)} + \frac{35}{(1+YTM)^2} + \frac{35}{(1+YTM)^3} \Rightarrow YTM = 15\%$$

Is this high or low?

A closer look

	Year			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
Bid #1a: Cisco (Costs)	-20	-35	-35	-35
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$$80 = \frac{35}{(1+YTM)} + \frac{35}{(1+YTM)^2} + \frac{35}{(1+YTM)^3} \Rightarrow YTM = 15\%$$

Loan interest rate (15%) > Cost of Capital (12%)

Lesson: IRR increased because initial investment fell more than future cash flows.

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(Intuition: Small payoffs on a smaller investment can generate very large returns because of division by small numbers.)

Lesson: NPV fell because Cisco is lending you money at an interest rate that is greater than your cost of capital.

Lesson: IRR can mislead when deciding among projects.

Lesson: NPV will not mislead in comparisons. The larger the NPV, the greater the value

ADDITIONAL BIDS

	Year			
	0	1	2	3
Bid #1: Cisco	-100	60	60	60
Bid #2: Juniper	-100	90	70	5
Bid #3: Huawei	-20	20	20	20

	Year			
	0	1	2	3
Bid #1: Cisco	-100	60	60	60
Bid #2: Juniper	-100	90	70	5
Bid #3: Huawei	-20	20	20	20

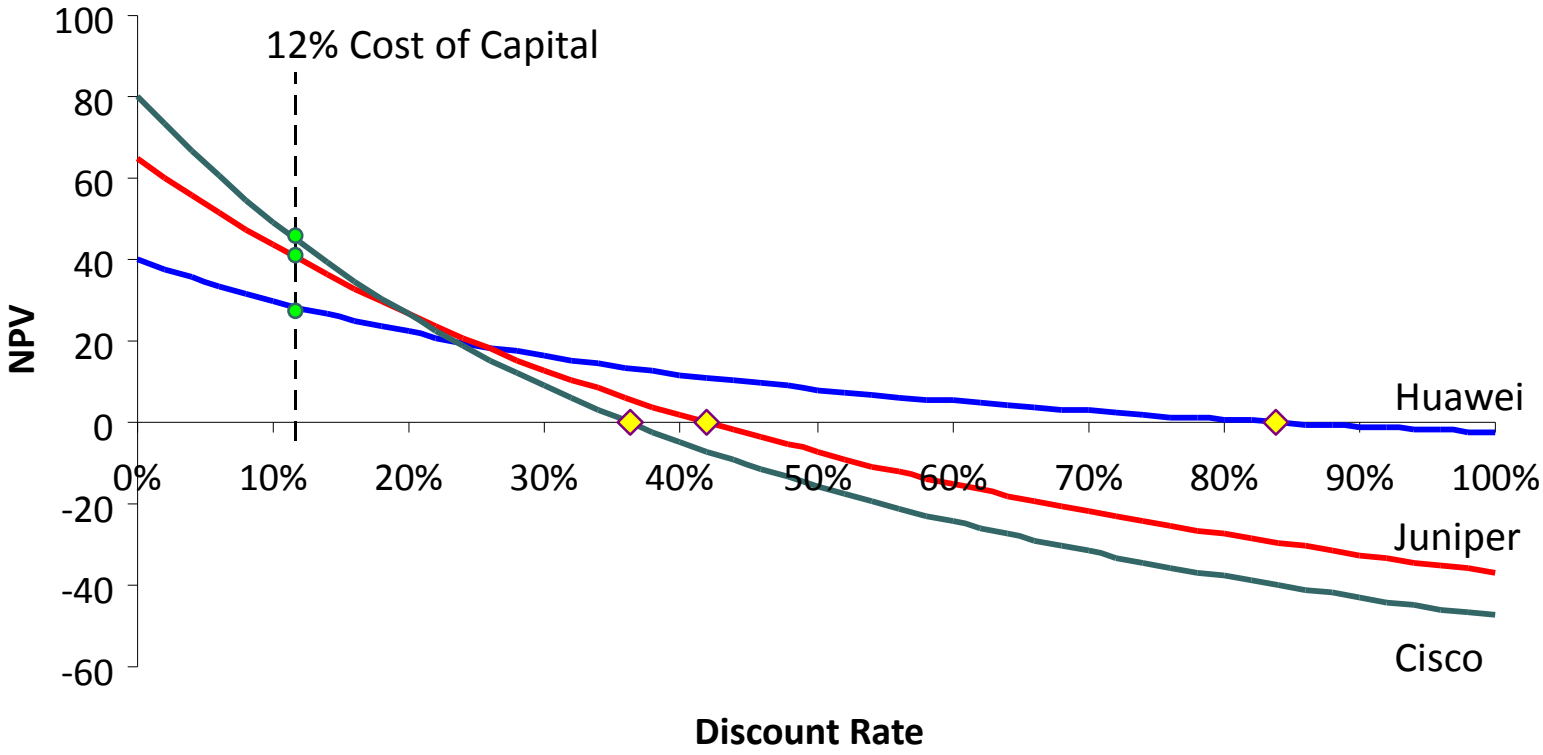
How would you rank the bids according to the IRR and the NPV criterion?

	Year					
	0	1	2	3	IRR	NPV
Bid #1: Cisco	-100	60	60	60	36%	44.11
Bid #2: Juniper	-100	90	70	5	42%	39.72
Bid #3: Huawei	-20	20	20	20	84%	28.04

	Year					
	0	1	2	3	IRR	NPV
Bid #1: Cisco	-100	60	60	60	36%	44.11
Bid #2: Juniper	-100	90	70	5	42%	39.72
Bid #3: Huawei	-20	20	20	20	84%	28.04

IRR: #3 > #2 > #1

NPV: #1 > #2 > #3



Intuition:

Huawei has small upfront cost → IRR ↑

Juniper has front-loaded CFs → IRR ↑

Lesson: IRR does not address differences in scale.

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Would you rather earn 100% on a $1 investment or 10% on a $1,000,000 investment?

Intuition:

Juniper's bid is like Cisco's with an embedded loan…

	Year			
	0	1	2	3
Bid #1: Cisco	-100	60	60	60
Bid #3: Huawei	-20	20	20	20
Bid #3: Huawei (Implicit Loan)	80	-40	-40	-40

Intuition:

Juniper's bid is like Cisco's with an embedded loan…with a 23% interest rate!

	Year				
	0	1	2	3	IRR
Bid #1: Cisco	-100	60	60	60	
Bid #3: Huawei	-20	20	20	20	
Bid #3: Huawei (Implicit Loan)	80	-40	-40	-40	23%

Summary

Lessons

- The internal rate of return of an asset is the one discount rate such that the NPV of the asset's free cash flows equals zero.

$$NPV = \frac{CF_1}{(1+IRR)} + \frac{CF_2}{(1+IRR)^2} + \frac{CF_3}{(1+IRR)^3} + \ldots + \frac{CF_T}{(1+IRR)^T} = 0$$

- The IRR Decision Rule says accept all projects whose $IRR > R$, reject all projects whose $IRR < R$ where R is the hurdle rate

Lessons

- IRR Rule can mislead decision making when cash flow signs are anything other than all negatives before all positives

- IRR Rule can mislead decision making when comparing projects even when cash flow signs are proper.
  - IRR does not account for differences in scale

Lessons

- IRR should be used in conjunction with NPV analysis

Coming up next

- Fixed Income Securities
  - Institutional environment
  - Valuation
  - Risk analysis