

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...

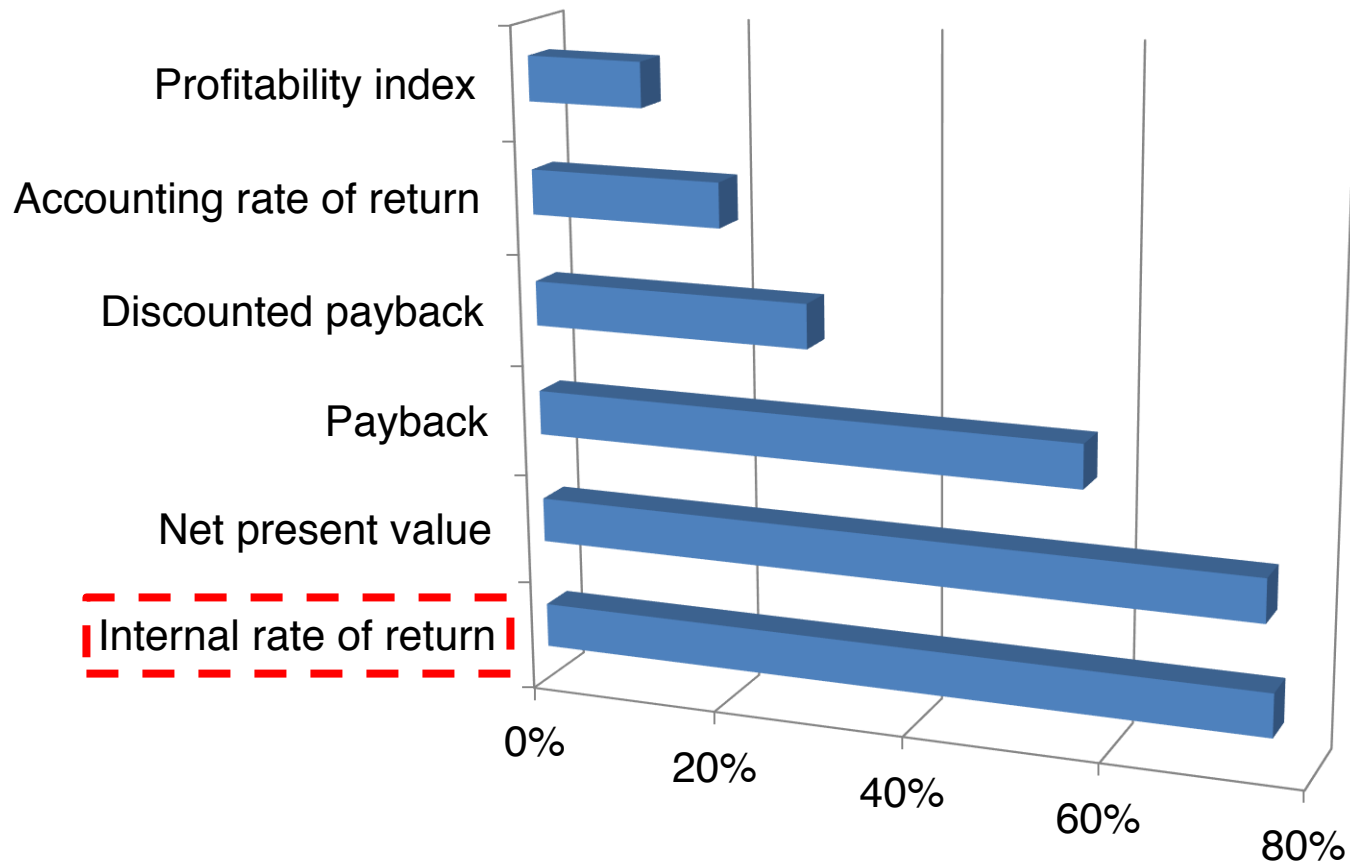
The **internal rate of return** of an asset is the one discount rate such that the NPV of the asset's free cash flows equals zero.

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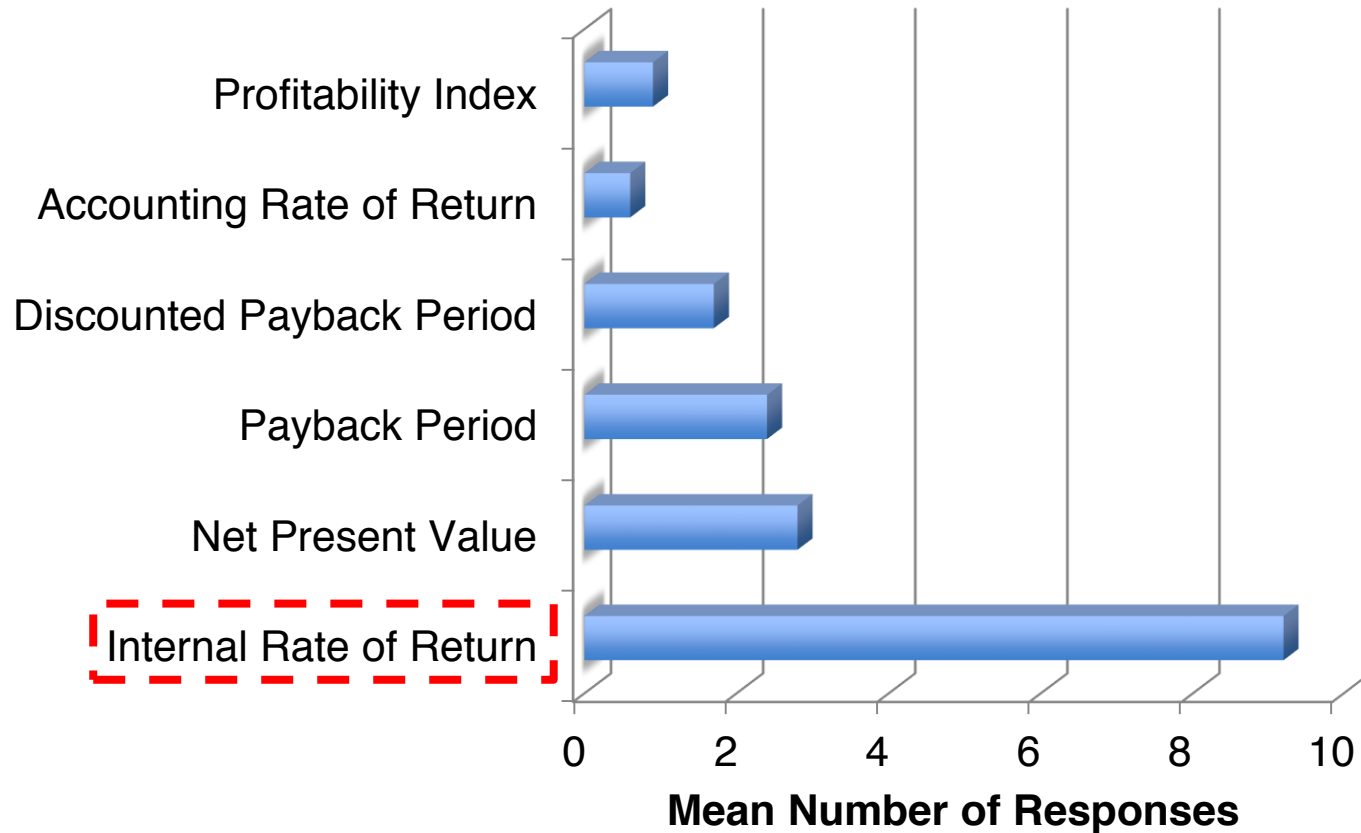
$$NPV = \frac{CF_1}{(1+IRR)} + \frac{CF_2}{(1+IRR)^2} + \frac{CF_3}{(1+IRR)^3} + \dots + \frac{CF_T}{(1+IRR)^T} = 0$$

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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and overhaul network infrastructure

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

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

	Year				
	0	1	2	3	IRR
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$IRR > R$ and CFs signs proper \rightarrow
Looks good!

Bid #1 from Cisco

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

	Year				IRR	NPV
	0	1	2	3		
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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$NPV > 0 \rightarrow$ Looks good!

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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

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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	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

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

	Year				IRR	NPV
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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	112%	40.05

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

Bid #1a from Cisco

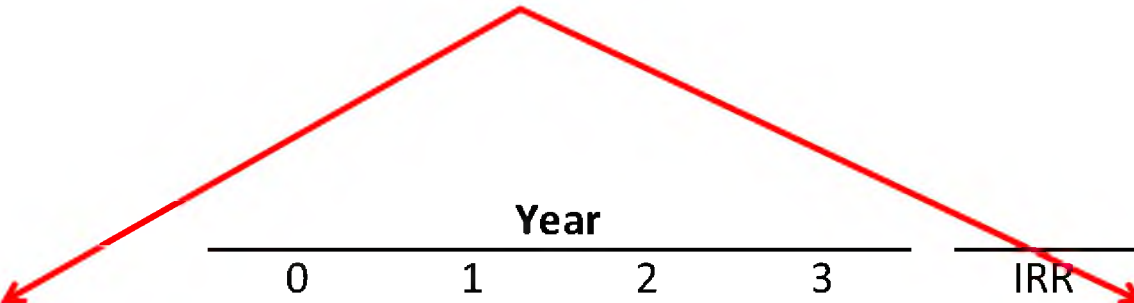
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Bid #1 NPV (\$44.11) > Bid #1a NPV (\$40.05)

What is going on?

NPV → Bid #1 is better



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	0	1	2	3	IRR	NPV
Bid #1: Cisco	-100	60	60	60	36%	44.11
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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			
	0	1	2	3
Bid #1: Cisco (Costs)	-100	0	0	0
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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
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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
Bid #1a: Cisco (Implicit Loan)	80	-35	-35	-35

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

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

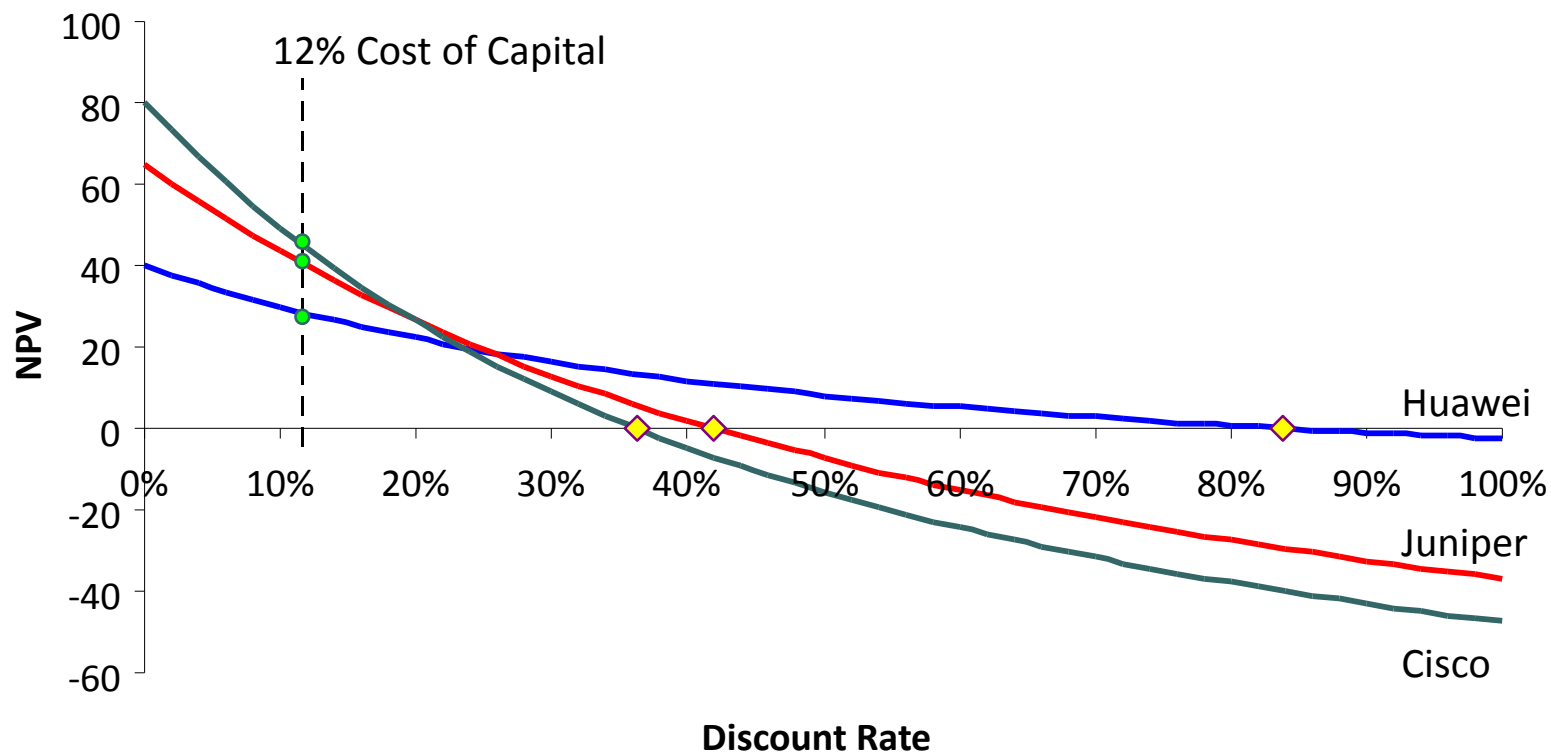
How would you rank the bids according to the IRR and the NPV criterion?

	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 \rightarrow IRR \uparrow

Juniper has front-loaded CFs \rightarrow IRR \uparrow

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.

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

- 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