Corporate Finance

Lecture 2: Capital Budgeting Method

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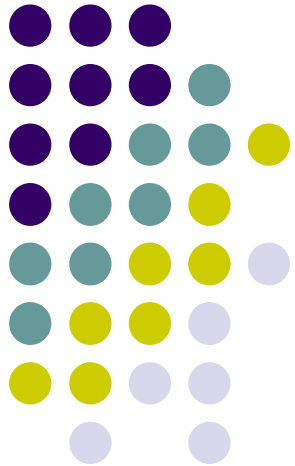

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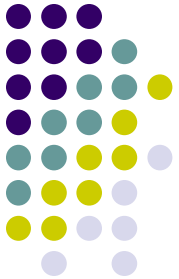
Net Present Value (NPV)

Recall:

- NPV measures how much a project **adds value** to a company.
- It is simply the present value of cash flows, calculated at the appropriate risk adjusted discount rate.

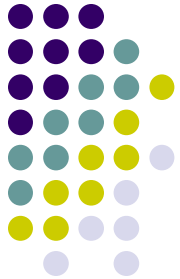
$$NPV = -C_0 + \sum_{t=1}^{T} \frac{C_t}{(1+r)^t}$$

NPV



- If cash flows and the discount rate are known, NPV is simple to compute.
- The challenging part of any NPV exercise is to figure out what are relevant cash flows. (next class)
  - The first cash flow is usually negative, representing an investment outlay.
  - Subsequent cash flows are usually positive, but not necessarily so.
- **The NPV rule is simple: if a project has positive NPV, then it should be accepted, otherwise not.**

Internal Rate of Return (IRR)



IRR is that discount rate for which the NPV of the investment is exactly zero.

- In general, $NPV(r) = -C_0 + PV(r)$
- In particular, $NPV(IRR) = -C_0 + PV(IRR) = 0$
- The PV of the future Cash Flows from the investment, discounted at the IRR rate, exactly equal the initial investment.
- Why does IRR represents a return?
- If the initial investment is invested at a rate equal to the IRR, then it can exactly replicate the future cash flows of that investment

IRR Project Accept/Reject Rule

The IRR is often as good a criterion as NPV.

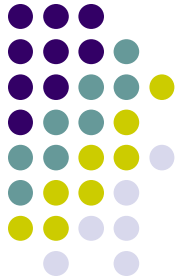
The IRR is that discount rate at which the NPV=0:

$$\sum_{t=0}^{T} \frac{C_t}{(1+\mathrm{IRR})^t} = 0$$

IRR Rule:

- Accept if IRR > actual discount rate
- Reject if IRR < actual discount rate

IRR & NPV



- If cash flows are *conventional*, (i.e. first negative and then always positive), the IRR criterion accepts a project if and only if its NPV is positive.
  - Why?
- Yet, in some situations, decision making within an organization may be easier if IRR rule is followed.
  - Example?

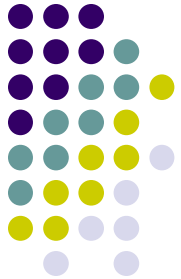
Why IRR?

- Return-based evaluations are easier for investors
  - Example: evaluating the performances of wealth management assets

Why IRR?

基金代码	基金名称	单位净值|日期	日增长率	近1周	近1月	近3月	近6月	近1年	近2年	近3年	今年来	成立来	手续费|起购金额	操作
014283	华夏北交所精选两年定开混合发起式	1.5728 11-20	2.93%	2.09%	36.69%	98.01%	74.43%	94.08%	123.85%	---	49.96%	57.28%	~~1.50%~~ 0.15% | 10元	买入
014279	汇添富北交所创新精选两年定开混合A	1.3085 11-20	3.10%	-1.74%	27.78%	93.83%	73.45%	80.82%	78.72%	---	49.25%	37.11%	~~1.50%~~ 0.15% | 10元	买入
014280	汇添富北交所创新精选两年定开混合C	1.2922 11-20	3.11%	-1.75%	27.74%	93.66%	73.12%	80.09%	77.29%	---	48.72%	35.48%	0.00% | 10元	买入
014275	易方达北交所精选两年定开混合A	1.4151 11-20	2.74%	-0.27%	31.88%	99.58%	83.48%	75.39%	56.33%	---	46.84%	43.70%	~~1.50%~~ 0.15% | 10元	买入
017512	广发北证50成份指数A	1.5479 11-20	2.83%	-2.09%	25.33%	106.99%	79.90%	74.77%	---	---	35.40%	54.79%	~~1.20%~~ 0.12% | 10元	买入
014276	易方达北交所精选两年定开混合C	1.4077 11-20	2.74%	-0.28%	31.82%	99.33%	83.02%	74.52%	54.77%	---	46.20%	41.57%	0.00% | 10元	买入
017513	广发北证50成份指数C	1.5393 11-20	2.83%	-2.09%	25.29%	106.84%	79.61%	74.23%	---	---	35.03%	53.93%	0.00% | 10元	买入
016307	景顺长城北交所精选两年定开混合A	1.7096 11-20	3.67%	-1.70%	24.45%	94.72%	73.32%	73.85%	73.81%	---	36.09%	70.98%	~~1.50%~~ 0.15% | 10元	买入
016308	景顺长城北交所精选两年定开混合C	1.6905 11-20	3.67%	-1.71%	24.39%	94.47%	72.87%	72.98%	72.08%	---	35.49%	69.07%	0.00% | 10元	买入
018128	博时北证50成份指数发起式A	1.5413 11-20	2.88%	-2.62%	23.92%	110.07%	81.74%	70.61%	---	---	35.57%	54.13%	~~1.00%~~ 0.10% | 10元	买入
014294	南方北交所精选两年定开混合发起	1.3755 11-20	2.17%	-0.88%	34.18%	81.46%	64.10%	70.05%	56.82%	---	35.45%	37.55%	~~1.50%~~ 0.15% | 10元	买入
018129	博时北证50成份指数发起式C	1.5301 11-20	2.88%	-2.63%	23.87%	109.86%	81.36%	69.92%	---	---	35.08%	53.01%	0.00% | 10元	买入
016325	泰康北交所精选两年定开混合发起A	1.8476 11-15	---	0.28%	36.76%	54.91%	42.44%	66.44%	---	---	25.53%	84.76%	~~1.50%~~ 0.15% | 10元	买入

Why IRR?



- Return-based evaluations are easier for investors
  - Example: evaluating the performances of wealth management assets
- The same mindset might be used when negotiating deals, especially when discount rate is hard to estimate
  - E.g. VC investments in startup companies

Major Drawbacks of IRR

IRR has two major drawbacks.

- If cash flows are not conventional, there may be multiple IRRs.
  - Which IRR to use?
- If projects are mutually exclusive, IRR may not be sufficiently informative.
  - Why?

Multiple IRRs – Example 1

Suppose cash flows are -60, 155 and -100

- e.g. a mining project: the last expense is the expenditure required to restore the terrain after the project is completed.

The IRR solves

$$-60 + 155/(1+IRR) - 100/(1+IRR)^2 = 0$$

- The solution yields two positive values of IRR, corresponding to the two roots of the equation.

IRR = 25% and IRR = 33.33 %.

- In general, the number of positive IRRs is at most equal to the number of sign changes in the cash flows, but could be less.
- In cases such as these, the IRR rule may lead to negative NPV projects being chosen.

Multiple IRRs – Example 2

A project has the following cash flows:

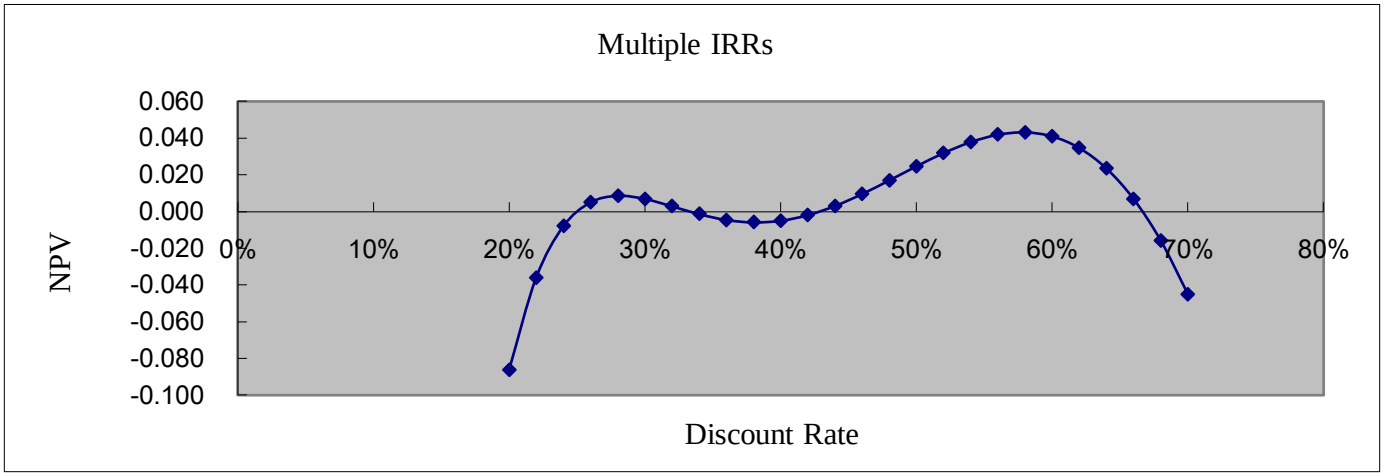
-252, 1431, -3035, 2850, -1000

The IRR solves:

$$-252 + 1431/(1+IRR) - 3035/(1+IRR)^2 + 2850 / (1+ IRR)^3 - 1000 / (1+IRR)^4 = 0$$

Verify that this project has the following IRRs:

IRR= ¼ , 1/3 , 3/7, 2/3 (i.e. 25%, 33.33%, 42.86% and 66.67%).



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$$-252 + 1431/(1+IRR) - 3035/(1+IRR)^2 + 2850 / (1+ IRR)^3 - 1000 / (1+IRR)^4 = 0$$

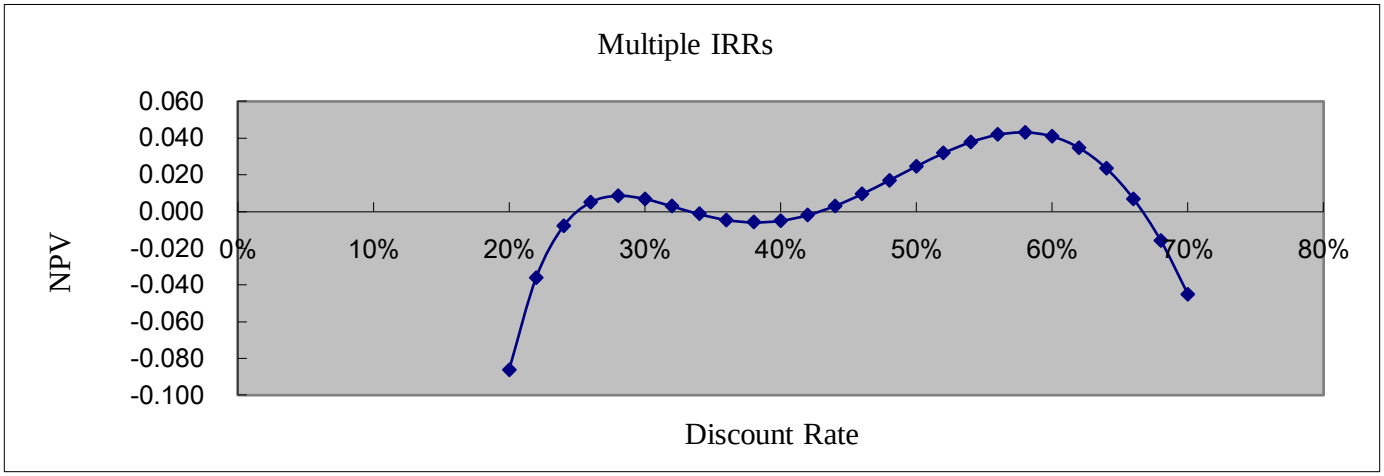
Verify that this project has the following IRRs:

IRR= ¼ , 1/3 , 3/7, 2/3 (i.e. 25%, 33.33%, 42.86% and 66.67%)

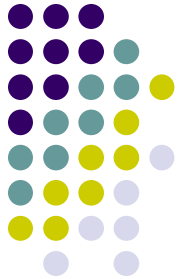
Question: what is the true hurdle rate of this project?

The issue: NPV is not a monotone function of discount rate!

- If our discount rate is 40%, this project is a negative NPV project.
- However, the project does have IRRs that are above 40%.
- The fact that the project has IRRs greater than the required rate of return does not mean that the project is profitable.
- In other words, the IRR criterion is not very helpful here.



Mutually Exclusive Projects



The IRR is also in trouble when dealing with mutually exclusive projects.

- In choosing between two projects, should we choose the one with higher IRR?
  - **No!** The answer depends on our **discount rate**.

The *crossover rate* is the one for which the projects have the same NPV.

Mutually Exclusive Projects

Year	0	1	2	3	4
Project A	-350	50	100	150	200
Project B	-250	125	100	75	50

How to Calculate the Crossover Rate?

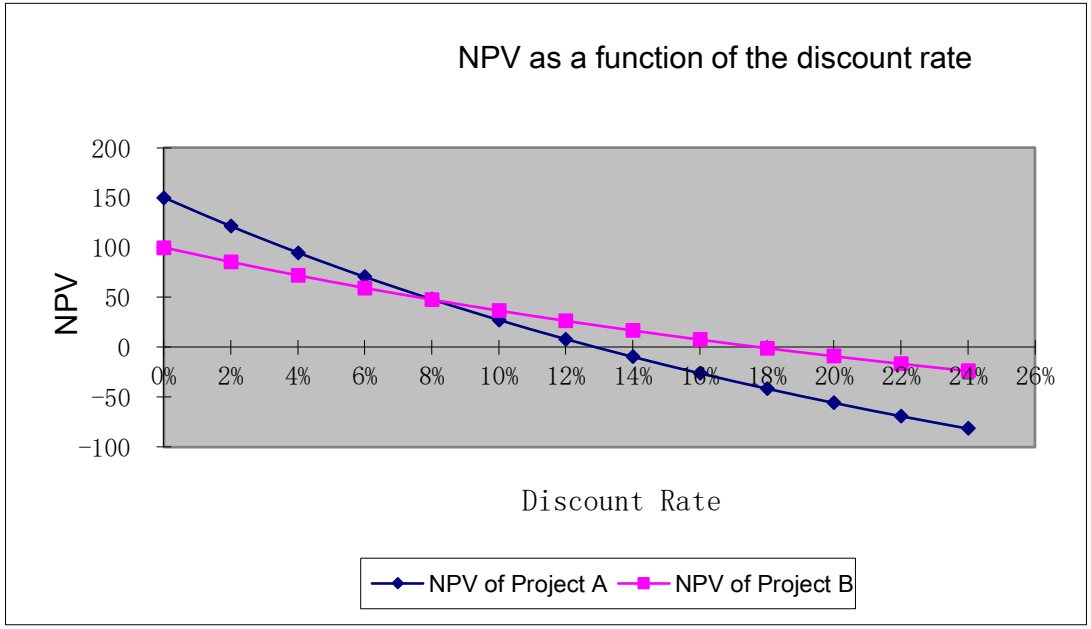
- Imagine C is another project, and
- Cash flows from C = Cash Flow from A – Cash Flow from B
- In the example in the graph, Cash Flows from C are : -100, -75, 0, 75, 150.
- Then the crossover rate between projects A and B is the IRR of project C.
  - Can you show why?

There can be multiple crossover rates.

- Can you show why?

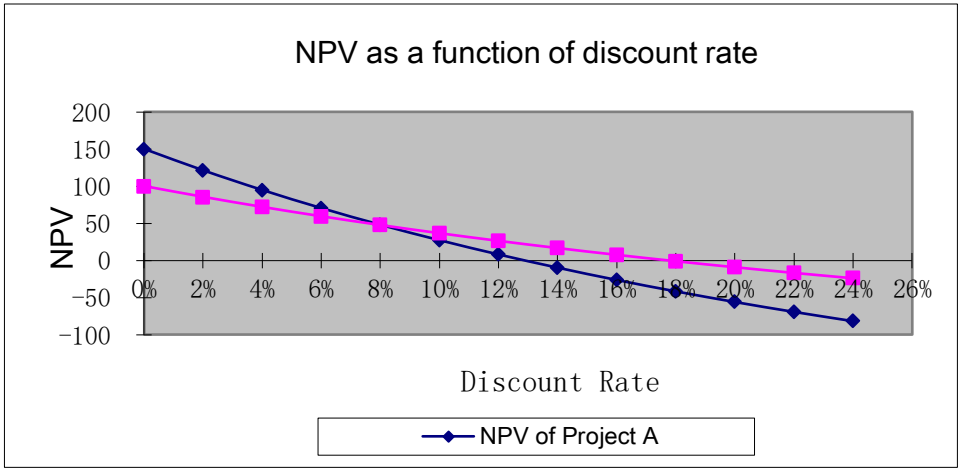
Mutually Exclusive Projects

- If the discount rate is above (below) the crossover rate, the project with higher (lower) IRR is preferred.
- The IRR criterion is NOT a good guide for choosing between mutually exclusive projects in this case.



Intuition:

Year	0	1	2	3	4
Project A	-350	50	100	150	200
Project B	-250	125	100	75	50



How desirable is Project A depends on your intertemporal elasticity of substitution.

Or how much you value your consumption in the future as compared to your consumption today!

Last class

NPV

- V_firm = V_oldfirm + NPV(project)
- Decision rule: a positive NPV project should be taken

IRR

- Discount rate s.t. NPV(IRR) = $-C_0$ + PV(IRR)=0
- Decision rule: accept if IRR > required discount rate/hurdle rate
- Benefit: return based decisions are easy to compare
- Drawbacks:
  - Unresolvable: multiple solutions if the sign of cash flow changes multiple times
  - Resolvable: mutually exclusive projects
    - Solution: still compare the two IRRs, but how to make the decision depends on the cross-over rate

Payback period method

IRR vs discount rate vs cross-over rate vs Cost of Capital

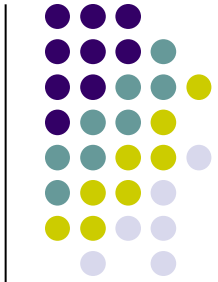
IRR

- A number that solves this equation:
  - NPV(IRR) = $-C_0$ + PV(IRR)=0
  - Is a feature pined down by the cash flows & price of an asset/project

Cross-over rate

- A number that solves this equation:
  - NPV1(CR) = NPV2(CR)
  - Is a feature pined down by the cash flows & price of two assets/projects

IRR vs discount rate vs cross-over rate

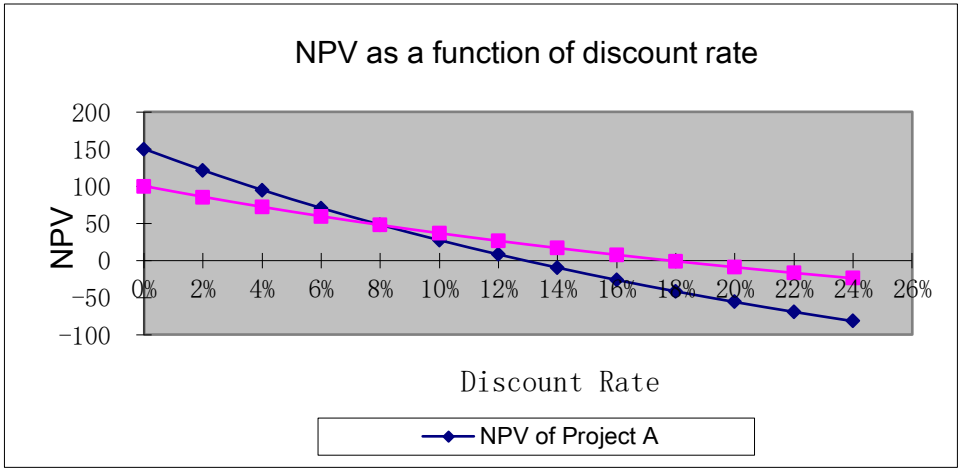


Discount rate

- A conversion_between a cash flow in the future and a cash flow happens today
- Determined by supply and demand in the market
- Affected by the following factors:
  - Time value of money (Intertemporal elasticity of substitution)
  - Inflation
  - Risk factors

Intuition:

Year	0	1	2	3	4
Project A	-350	50	100	150	200
Project B	-250	125	100	75	50



How desirable is Project A depends on your intertemporal elasticity of substitution.

Or how much you value your consumption in the future as compared to your consumption today!

Exercise

Ch5-11 NPV versus IRR Consider the following cash flows on two mutually exclusive projects for the Bahamas Recreation Corporation (BRC). Both projects require an annual return of 14 percent. As a financial analyst for BRC, you are asked the following questions:

a. If your decision rule is to accept the project with the greater IRR, which project should you choose?

b. Because you are fully aware of the IRR rule's scale problem, you calculate the incremental IRR for the cash flows. Based on your computation, which project should you choose?

c. To be prudent, you compute the NPV for both projects. Which project should you choose? Is it consistent with the incremental IRR rule?

	Deepwater	New Submarine
Year	Fishing	Ride
0	−$725,000	−$1,450,000
1	270,000	820,000
2	420,000	650,000
3	380,000	540,000

Exercise

a. Deepwater IRR = 20.96%; Submarine Ride IRR = 19.87%.

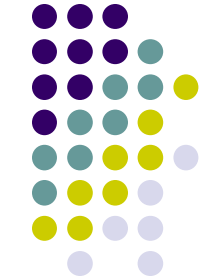
b. Cash Flows (Submarine – Deepwater):

-725,000, 550,000, 230,000. 160,000

- IRR (crossover) = 18.4%.
- Since the incremental IRR, 18.40 percent, is greater than the required rate of return of 14 percent, choose the submarine ride project.

a. Deepwater NPV = $91,507.64 ; Submarine NPV = $133,936.76

Other Criteria: Payback Period Rule



Payback period:

- The amount of time required for an investment to generate cash flows to recover its initial cost

Criterion :

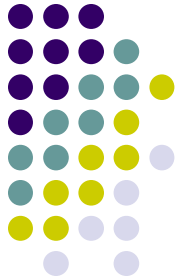
- An investment is acceptable if its calculated payback period is less than some pre-specified number of years.

Payback Period Rule – Example 1

Year	Cash Flow	Cumulative Cash Flow
0	-60	-60
1	20	-40
2	30	-10
3	40	+30
4	25	+55
5	22	+77
6	10	+87
7	0	+87

- Suppose the cumulative sum of cash flows becomes positive for the first time in year T.
- Payback period = (T-1) - [(Cumulative SumT-1) / (Cash Flow)T]
- Thus, in the example, T = 3 and
- Payback period = (3-1) – [-10/40] = 2.25 years (linear interpolation)

Payback Period Rule



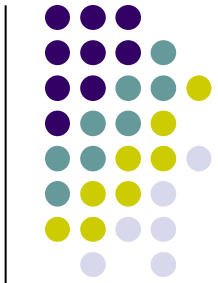
Disadvantages

- Ignores time value of money and risk differences
- Requires an arbitrary cutoff point with no economic background
- Ignores cash flow beyond cutoff date
- Biased against long-term investment

Advantages

- Easy to understand and simple to use
- Adjusts for uncertainty of later cash flows by ignoring them
- Biased toward liquidity
  - For firms relying on internal funds for new projects, emphasis on quick payback makes sense.

Application: fixed income duration (for fun for now)



Definition: how long it takes, in years, for an investor to be repaid a bond's price through its total cash flows.

- Similar to payback period, but do adjust for time value
- Duration can also be used to measure how sensitive the price of a bond or fixed-income portfolio is to changes in interest rates.
- As a bond's duration rises, its interest rate risk also rises, so duration can be used to identify risk.
- The Macaulay duration: the weighted average time until all the bond's cash flows are paid.

Application: fixed income duration (for fun for now)

$$MacD = \sum_{f=1}^{n} \frac{CF_f}{\left(1 + \frac{y}{k}\right)^f} \times \frac{t_f}{PV}$$

where:

f = cash flow number

CF = cash flow amount

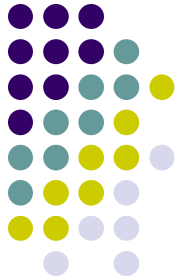
y = yield to maturity

k = compounding periods per year

t_f = time in years until cash flow is received

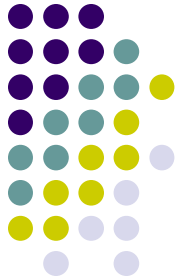
PV = present value of all cash flows

Application: fixed income duration (for fun for now)



The formula is divided into two sections. The first part is used to find the present value of all future bond cash flows. The second part finds the weighted average time until those cash flows are paid. When these sections are put together, they tell an investor the weighted average amount of time to receive the bond's cash flows.

Average Accounting Return (AAR)



AAR= average net income/average book value

Criterion :

- A project is acceptable if its AAR exceeds a target (e.g. ROA or ROE)

Advantages

- Easy to calculate
- Needed information is available

Disadvantages

- Not a true rate of return and time value of money is ignored.
- Uses arbitrary benchmark cutoff rate
- Based on accounting value, not cash flows and market value.

AAR – An Example

	YEAR 1 (BEG)	Year 1 (END)	Year 2 (END)	Year 3 (END)
INVESTMENT	240	0	0	0
BOOK VALUE[1]	240	160	80	0
SALES		440	240	160
COSTS		220	120	80
GROSS PROFIT		220	120	80
DEPRECIATION		80	80	80
EBT (Earnings Before Taxes)		140	40	0
TAXES (25%)		35	10	0
NET INCOME		105	30	0
AVERAGE NET INCOME	= (105+30+0)/3 = 45			
AVERAGE BOOK VALUE	= (240+ 160+80+0)/4 = 120, OR (240+0)/2 = 120[2]			
AAR	(Average Net Income)/(Average Book Value) = 45/120=37.5%			

[1] We have assumed that the initial investment is depreciated according to the straight line method. The depreciation each year is 240/3=80.
[2] Under the straight line method, the average book value is also calculated as (initial book value + final book value)/2.

Profitability Index

- **Profitability Index (PI) = (I+ NPV) / I= PV/ I**
  - I denotes the initial investment
  - PV denotes the present value of cash flows that occur after the initial investment
- **Independent project**
  - NPV>0 ↔ PI >1
- **Mutually exclusive projects**
  - Do "higher NPV" and "higher PI" rules point to the same choice?
    - Not always, PI ignores the size of investment.
  - What if you have a tight budget and each project can be **scaled up and down** with **constant PV per dollar**?
    - Then you should choose the project with the highest PI.

Exercise

Ch5-15 Profitability Index versus NPV Hanmi Group, a consumer electronics conglomerate, is reviewing its annual budget in wireless technology. It is considering investments in three different technologies to develop wireless communication devices. Consider the following cash flows of the three independent projects available to the company. Assume the discount rate for all projects is 10 percent. Further, the company has only $43 million to invest in new projects this year.

a. Based on the profitability index decision rule, rank these investments.

b. Based on the NPV, rank these investments.

Cash Flows (in $ millions)			
Year	CDMA	G4	Wi-Fi
		–	–
0	−$18	$25	$43
1	23	21	39
2	16	51	66
3	6	41	42

*The three projects are mutually exclusive

Exercise

a. PI(CDMA) = 2.15;

   PI(G4) = 3.68;

   PI(WIFI)=2.83.

   So, G4>WIFI>CDMA

a. NPV(CDMA) = $20,640,120.21;

   NPV(G4) = $67,043,576.26;

   NPV(WIFI) = $78,555,221.64.

   So, WIFI>G4>CDMA

Exercise

- What if you have three agricultural projects with the following cash flow, and each project can be scaled up and down with constant PV per dollar invested?
- Do you need to know your initial budget for making the decision?

CF\t=	0	1	2	3
Orange	-18	23	16	6
Apple	-25	21	51	41
Pear	-43	39	66	42

				Initial Budget		
				43	25	18
	PV(t=(1,3)	**NPV**	**PI**	**Scaled NPV**		
Orange	¥38.64	¥20.64	2.15	¥49.31	¥28.67	¥20.64
Apple	¥92.04	¥67.04	3.68	¥115.31	¥67.04	¥48.27
Pear	¥121.56	¥78.56	2.83	¥78.56	¥45.67	¥32.88

Takeaways