Investment Decision Rules

Required Reading

- **Chapter 8,** "*Investment Decision Rules*" from J. Berk et al., Fundamentals of Corporate Finance, Second Canadian Edition.

The Net Present Value (NPV) Rule

Capital Budgeting: The process of planning a firm's investment.

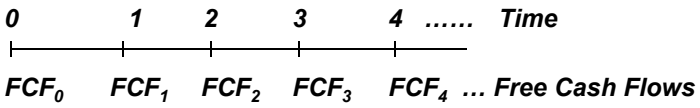
Q. When should a firm undertake an investment?

When it creates value for the owners of the corporation (the shareholders).

Q. When does an investment create value?

An investment creates value if the project has a positive NPV.

The Net Present Value (NPV) Rule



Consider an investment that generates the above stream of free cash-flows. The net present value (NPV) of this investment is :

$$NPV = \sum_{t=0}^{\infty} \frac{FCF_t}{(1+r)^t}$$

where FCF_t is the free cash-flow that arrives at date t and r is the cost of capital associated to the project (which is determined by the market return of other projects of similar risk).

The Net Present Value (NPV) Rule

- **For a single project:** Undertake if and only if its NPV is positive.
- **For many independent projects:** Undertake all positive NPV projects.
- **For mutually exclusive projects:** Among the positive NPV projects, choose the one with the highest NPV.
- **When there is a budget constraint**: When there is a fixed investment budget that cannot be exceeded, the company should undertake the bundle of investments generating the highest total NPV.

Example

Researchers SFL Inc. can create a new fertilizer. The fertilizer will require a new factory that can be built at a cost of $81.6 million. Estimated return on the new fertilizer will be $28 million after the first year, and last four years. If the project's cost of capital is 10%, should SFL lunch the project?

Solution

$$NPV = -81.6 + \frac{28}{0.1}\left(1 - \frac{1}{(1+0.1)^4}\right) = \$7.2 \text{ million}$$

$\Rightarrow$ Since NPV > 0, SFL should take project

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Example

You own a pharmaceutical firm. You are considering launching **one** of two alternative drugs (cannot launch both). Based on the information below, should you launch Drug A, Drug B, or not launch any of the two drugs ?

	Initial Investment	Cash flow in the First Year	Growth Rate	Cost of Capital
Drug A	$200,000	$30,000	3.5%	12%
Drug B	$100,000	$20,000	3%	10%

Solution

$$NPV_A = \frac{30{,}000}{0.12 - 0.035} - 200{,}000 = \$152{,}941$$

$$NPV_B = \frac{20{,}000}{0.1 - 0.03} - 100{,}000 = \$185{,}714$$

Both alternatives (Drug A and Drug B) have positive *NPV*s, but you can only take one of them. Hence, you should choose the one that creates the most value (i.e., the one with the highest NPV). In this case **Drug B.**

Investment with Unequal Lives

- Mutually exclusive investments with unequal lives.

  → If the investments are taken only once then take the one with the highest NPV

  → If the investments are repeated over time then it is necessary to examine the investments over a common time horizon.

Let's see an example…

Example

The cafeteria is deciding whether to install a expensive (E) or a Cheap (C) vending machine. Machine E lasts for nine years and in those nine years generates an NPV of $1,200. Machine C lasts for six years and in those six years generates an NPV of $800. Assume that discount rate is 10%. Which machine should the cafeteria install if it plans to keep replacing the machines after they become obsolete?

Solution

We will compare both options over a common horizon. In this case two E-machines last for 18 years, the same as 3 C-machines. Therefore:

$$NPV_{E+E} = 1{,}200 + \frac{1{,}200}{(1.1)^9} = \$1{,}709$$

$$NPV_{C+C+C} = 800 + \frac{800}{(1.1)^6} + \frac{800}{(1.1)^{12}} = \$1{,}506$$

- An alternative method to compare mutually exclusive investments with unequal lives that are repeated over time is the use of the **Equivalent Annual Annuity (EAA).** The **EAA** is the annuity that if received over each year of a specified investment would yield the same NPV as the investment.

$$\boldsymbol{NPV_E = \frac{EAA_E}{r}\left(1 - \frac{1}{(1+r)^{T_E}}\right) \Rightarrow EAA_E = \frac{r \cdot NPV_E}{\left(1 - \frac{1}{(1+r)^{T_E}}\right)}}$$

$$\boldsymbol{NPV_C = \frac{EAA_C}{r}\left(1 - \frac{1}{(1+r)^{T_C}}\right) \Rightarrow EAA_C = \frac{r \cdot NPV_C}{\left(1 - \frac{1}{(1+r)^{T_C}}\right)}}$$

"Take the project with the highest EAA"

Back to our example:

$$EAA_E = \frac{r \cdot NPV_E}{\left(1 - \frac{1}{(1+r)^{T_E}}\right)} = \frac{0.1 \cdot 1200}{\left(1 - \frac{1}{(1.1)^9}\right)} = \$208$$

$$EAA_C = \frac{r \cdot NPV_C}{\left(1 - \frac{1}{(1+r)^{T_C}}\right)} = \frac{0.1 \cdot 800}{\left(1 - \frac{1}{(1.1)^6}\right)} = \$184$$

"Buy the expensive (E) vending machine"

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Example

The firm has four ***independent*** investments:

Investment	Initial Investment	NPV
A	$200,000	$10,000
B	$120,000	$8,000
C	$50,000	$6,000
D	$80,000	$5,000

Which projects will the firm take if it has an investment budget of $200,000?

Projects B and C

Which projects will the firm take if it has an investment budget of $250,000?

Projects B, C, and D

Q. Why does a positive NPV investment create value? Because a positive NPV investment provides a higher return than what the market offers for investments of *similar risk*.

Q. Is the NPV rule too mechanical? The actual process of discounting is very simple the difficult thing is coming up with the estimated free cash flows and the discount rate in the first place.

Where Do Positive NPV Projects Come From?

- A positive NPV means that:

  → ***The investor is "more than compensated" for the risk of the investment.***

  (or equivalently)

  → ***The investor earns economic profits***

- In doing valuation you need to go beyond the numbers, you need to *UNDERSTAND* the economics of the project:

  "Smart managers do not accept positive NPV unless they can explain them" (Myers, JACF 1987)

Sources of Competitive Advantage

- In competitive markets a firm can achieve NPV>0 only if

  I. Firm has have some advantage over their competitors

  II. Project is a "short-run" deviation from equilibrium (i.e., luck)

- ***Ask yourself***: Which is the comparative advantage that allows the firm to earn economic profits (the existence of a positive NPV project)?

Alternative Investment Rules (and their shortcomings)

- Payback Period (PP)
- The Internal Rate of Return (IRR)
- Profitability Index (PI)

Payback Period (*PP*)

- The **Payback Period** (***PP***) is the minimum amount of time T^* required to recoup the initial investment at *t=0.*

$$\sum_{i=1}^{T^*} FCF_i \geq -FCF_0 \equiv I_0$$

- **Payback Period Rule:** Choose a hurdle $\boldsymbol{T^H}$ (number of periods) and:

  → *For independent projects*: Undertake all projects with $\boldsymbol{PP \leq T^H}$.

  → *For mutually exclusive projects*: Among all the projects having $\boldsymbol{PP \leq T^H}$, undertake the one with the shortest ***PP***.

Example: Consider project X with a cut-off point (or hurdle) T^H =2:

	FCF_0	FCF_1	FCF_2	FCF_3	FCF_4	***PP***
Project X	-30	10	10	10	10	***3***

According to PP project X is not undertaken i.e., 3 > T^H =2.

Payback Period (*PP*): Caveats

Caveats with *PP* rule:

- Requires an arbitrary cut-off point ***T^H***
- No discounting: Ignores the time value of money and the risk
- It ignores the FCF beyond the cutoff point.
- It is insensitive to scale

Q. Why are these caveats a problem?

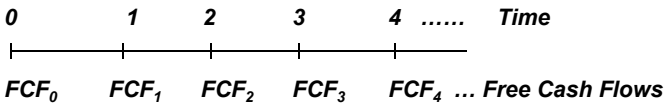
Because it can lead to wrong investment decisions (e.g., undertake negative NPV projects and reject positive NPV ones).

Example: (*PP ignores FCF after the cut-off*)**:** Consider project E with cost of capital r =10% and a cut-off point (or hurdle) T^H =3:

	FCF_0	FCF_1	FCF_2	FCF_3	FCF_4	***PP***	***NPV***
Project E	-100	0	0	0	300	***4***	***104.9***

According to PP project E is not undertaken but it should be undertaken (i.e., NPV>0).

Internal Rate of Return (*IRR*)



Consider an investment that generates the above stream of FCF. The ***Internal Rate of Return (IRR)*** of the investment is the constant discount rate that makes its NPV equal to zero.

$$\sum_{t=0}^{\infty} \frac{FCF_t}{(1+IRR)^t} = 0$$

• ***IRR Rule*****:** Let ***r*** be the project's cost of capital then:

→ *For independent projects*: Undertake all projects with ***IRR ≥ r***.

→ *For mutually exclusive projects*: Among all the projects with an ***IRR ≥ r***, undertake the one with the highest ***IRR.***

Internal Rate of Return (*IRR*): Caveats

Caveats with *IRR* rule:

- IRR rule may lead to the wrong ranking of mutually exclusive projects.
- It is insensitive to scale.
- With no conventional FCF there may be no IRR or there might be more than one. (**Note**: A conventional FCF stream refers to an initial investment in period 0 follow by non-negative FCF thereafter.)

Q. Why are these caveats a problem?

Because it can lead to wrong investment decisions (e.g., undertake negative NPV projects).

Example 1 (*Unconventional FCF*)

Consider the following project:

FCF_0	FCF_1	*IRR*
100	-115	15%

- Assume that the cost of capital is 10%. Would you take the project according to the NPV rule?

$$NPV = 100 + \frac{-115}{1+0.1} = -5.54 < 0 \rightarrow \text{Reject}$$

But the IRR rule recommends taking a negative NPV project !!

- Assume that the cost of capital is 20%. Would you take the project according to the NPV rule?

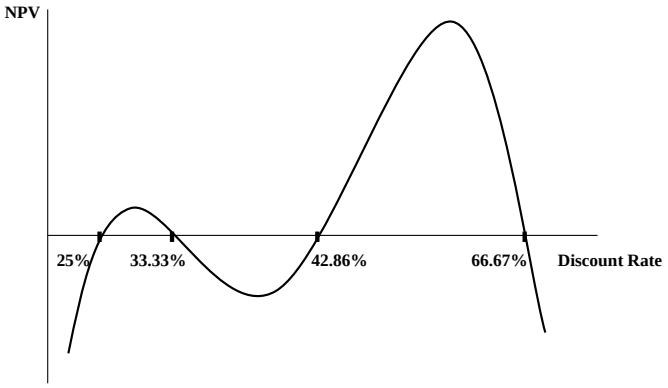
$$NPV = 100 + \frac{-115}{1+0.2} = 4.16 > 0 \rightarrow \text{Accept}$$

But the IRR rule recommends rejecting a positive NPV project !!

Example 2 (*Unconventional FCF*)**:**

Calculate the IRR for this project:

FCF_0	FCF_1	FCF_2	FCF_3	FCF_4
-252	1431	-3035	2850	-1000



Hence the project has multiple IRR (i.e., four) !!

Example 3 *(Mutually Exclusive Projects)*

Consider the following two mutually exclusive projects. Calculate their IRR and their NPV for the following alternative costs of capital: 100%, 30.17%, 21.01%, 15%, 10% and 1%.

	FCF_0	FCF_1	FCF_2
Project A	-280	280	110
Project B	-480	390	231

Solution

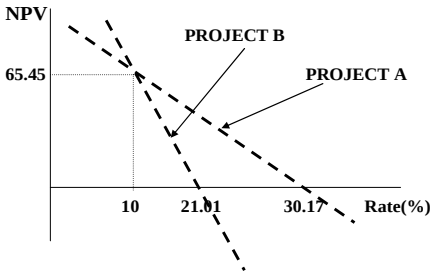
$$-280+\frac{280}{1+IRR_A}+\frac{110}{(1+IRR_A)^2}=0 \Rightarrow IRR_A=30.17\%$$

$$-480+\frac{390}{1+IRR_B}+\frac{231}{(1+IRR_B)^2}=0 \Rightarrow IRR_B=21.07\%$$

According to the *IRR* project A is always preferred to project B, and it should be undertaken if the projects' cost of capital is smaller than 30.17%

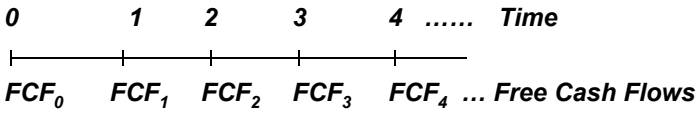
Solution (cont)

	Project A	Project B
NPV @ 100%	-112.5	-227.25
NPV @ 30.17%	0	-44.06
NPV @ 21.01%	26.50	0
NPV @ 15%	46.56	33.79
NPV @ 10%	65.45	65.45
NPV @ 1%	105.06	132.59



If the discount rate is above (below) 10% project A has a higher (lower) NPV than project B. However, the IRR rule always chooses project A over B.

Profitability Index (*PI*)



The ***Profitability Index*** is ratio of the project's NPV over the initial investment.

$$PI = \frac{NPV}{-FCF_0} = \frac{\sum_{t=0}^{\infty} \frac{FCF_t}{(1+r)^t}}{-FCF_0}$$

- ***PI Rule*:**

  → *For independent projects*: Undertake all projects with ***PI ≥ 0***.

  → *For mutually exclusive projects*: Among all the projects with an ***PI ≥ 0***, undertake the one with the highest ***PI.***

Profitability Index (*PI*): Caveats

Caveats with *PI* rule:

- It is insensitive to scale.

Q. Why is this caveat a problem?

Because it can lead to the wrong ranking of mutually exclusive projects.

Example *(Mutually Exclusive Projects)*

Consider the following two mutually exclusive project whose cost of capital is 10%. Calculate their NPV and PI.

r = 10%	FCF_0	FCF_1	*NPV*	*PI*
Project *I*	-100	200	81.82	0.81
Project *II*	-10	25	12.73	1.27

*The **PI** rule selects **Project II** while **Project I** has a higher NPV. This is because the **PI** rule is not sensitive to changes in the scale of the project.*

What Do CFO's Use in Practice?