# CHAPTER 7: NPV AND CAPITAL BUDGETING

Assigned problems are 3, 7, 34, 36, and 41. Read Appendix A.

## I. Introduction

The key to analyzing a new project is to think *incrementally*. We calculate the incremental cash flows that are associated with the project, i.e., how will the corporation's total *after-tax* cash flows change if this project is accepted.

(1) Don't forget about future inflation when estimating future cash flows!

(2) Include all side effects: the project may harm or enhance existing operations.

(3) Do not include *sunk* costs: any money spent in the past is irrelevant. The only cash flows that matter are those that occur now and in the future.

(4) Include any *opportunity* costs. Any asset used for a project might have a higher value in some alternative use. A hypothetical example follows.

**Example of opportunity cost:** Let r=10%. An existing asset belonging to a firm is to be used to support a proposed project. The asset can be sold now for $100,000 or in five years for $120,000. There is an opportunity cost to not selling the asset today.

NPV of foregone opportunity = $-100{,}000 + 120{,}000/(1+0.10)^5 =$ -$25,489

Perhaps it might be more economical to sell this asset today and to purchase or lease a similar asset.

Business investment requires investment in two types of assets: *long-term* and *short-term* assets. The long-term assets are the plant, property, and equipment, i.e., assets that will be depreciated over the coming years. The short-term assets include the increased cash, accounts receivable, or inventory that is necessary to support a project.

Any increase in *short-term* assets that is funded or financed with *long-term* sources is called *Net Working Capital* and must be included in the calculation of a project's NPV.

**Example:** Let r=10%. A project requires an initial increase of $10,000 in additional cash and inventory to support it over its 5-year life. This $10,000 will be recovered at the termination of this project in five years. While this $10,000 is tied up for the project, it can't be invested elsewhere in the firm or be distributed to the shareholders, and thus we can estimate the effect of this foregone opportunity.

NPV of foregone opportunity = $-10{,}000 + 10{,}000/(1+0.10)^5$ = <u>-$3791</u>

Anything that reduces the amount of resources tied up in cash and inventory would increase the NPV of the project.

## <u>II. Cash Flow Estimation</u>

(1) The <u>initial cost</u> of a project, referred to as Net Investment (NINV) or $CF_0$, is calculated as:

Equipment
+ Shipping/installation
**Installed Cost** (a)
+ Initial increase in Net Working Capital
– Proceeds from sale of existing assets
**Net Investment before taxes**
+ Tax on sale of existing assets (b)
**Net Investment**

**<u>Notes concerning calculation of initial investment:</u>**

(a) The Installed Cost is the amount that is depreciated over the life of the project.

(b) If sale amount > remaining book value:

tax paid = [tax rate][sale price – book value]

If sale amount < remaining book value, then a tax credit exists, using this formula

Book Value ≡ Installed Cost – Cumulative Depreciation

(2) The <u>annual net after-tax *incremental* cash flows</u> $CF_1$ through $CF_n$ must be estimated. The general formula follows:

$\Delta CF_i$ =[Δrevenue – Δcosts – Δdepreciation][1 – tax rate] + Δdepreciation – ΔNWC (a) +/– Salvage or Terminal (b) cash flows

**<u>Notes concerning calculation of annual net cash flows:</u>**

(a) ΔNWC represents changes in Net Working Capital. ΔNWC is *positive* when additional investment in NWC is needed.

(b) The Salvage or Terminal cash flows include such items as: sale of assets and taxes on the sale of those assets, and costs associated with the disposal of a project, e.g., environmental cleanup costs.

The net cash flows always ignore the interest costs associated with any debt financing. Thus these cash flows are calculated as if the project were all equity financed. The actual interest cost of any debt financing is reflected in the cost of capital *r* that is used to calculate the NPV. The cost of capital *r* is a weighted average of the costs of the debt and equity capital used (covered in Ch. 12 & 17).

# III. Project Cash Flow and NPV Example

A firm has a proposed 5-year project. If accepted today (t=0), the project is expected to generate positive net cash flows for each of the *following* five years (t=1 through t=5). A new machine will be put in service, and to implement this project, an old machine will be sold. Note the following items:

• The new machine costs $1,000,000. Shipping and installation will cost an additional $500,000. Thus the Installed Cost is $1,500,000.

• This new machine will be sold five years from today when this project is completed. We believe that it can be sold for $100,000 in five years.

• If this project is accepted, then an old, fully depreciated, machine will be replaced. The old machine can be sold for $50,000 today.

• The Installed Cost of this new asset will be depreciated using the IRS 5-year MACRS schedule: year 1, 20%; year 2, 32%; year 3, 19.2%; year 4, 11.52%; year 5, 11.52%; and year 6, 5.76%. Note that these yearly amounts sum to 100%.

• The project will increase revenues and operating expenses (before depreciation and amortization) by $800,000 and $300,000 per year, respectively, for each of the following five years (t=1 to t=5).

• An initial increase in Net Working Capital of $50,000 is required today and this amount will be recovered in 5 years when the project is terminated. No other changes in NWC will be required during the project's life.

• The cost of capital of the project is r=11%. The corporate income tax rate is 40%.

## Calculation of the project's Initial Investment or $CF_0$:

The old machine is sold for $50,000 today and has no remaining book value (fully depreciated). The tax owed on the sale of the old machine is calculated as:

tax paid = [tax rate][sale price – book value] = [0.40][50,000 – 0] = $20,000

| | |
|---|---:|
| Equipment | 1,000,000 |
| + Shipping/installation | 500,000 |
| **Installed Cost** | **1,500,000** |
| + Initial increase in Net Working Capital | 50,000 |
| – Proceeds from sale of existing assets | 50,000 |
| **Net Investment before taxes** | **1,500,000** |
| + Tax on sale of existing assets | 20,000 |
| **Net Investment** (an outflow) | **1,520,000** |

If accepted, this project requires an initial outlay of $1,520,000 cash today. Thus $CF_0$ = -$1,520,000.

## Calculation of the project's future Net Cash Flows:

First, calculate the annual depreciation expense (depreciation is a *non-cash* expense). Note that an IRS 5-year schedule covers six years. The total amount to be depreciated is the original Installed Cost of $1,500,000.

| Year | Annual Depreciation Expense |
|---|---:|
| 1 | [0.20][1,500,000] = $300,000 |
| 2 | [0.32][1,500,000] = $480,000 |
| 3 | [0.192][1,500,000] = $288,000 |
| 4 | [0.1152][1,500,000] = $172,800 |
| 5 | [0.1152][1,500,000] = $172,800 |
| 6 | [0.0576][1,500,000] = $86,400 |

Note that this project is terminated exactly five years from today at t=5, so the last amount to be depreciated is the Year 5 amount of $172,800. The Year 6 depreciation of $86,400 is never expensed. Therefore, when the project is terminated at t=5, the *remaining* accounting Book Value of this asset will be $86,400.

When the project is terminated five years from today (t=5), some salvage or terminal cash flows must be calculated. The machine will be sold for $100,000 at that time. The remaining book value will be $86,400. Therefore, the taxes owed at that time on the sale will be:

[tax rate][sale price – book value] = [0.40][100,000 – 86,400] = $5440

Now we calculate annual after-tax incremental cash flows $\Delta CF_1$, $\Delta CF_2$, $\Delta CF_3$, $\Delta CF_4$, and $\Delta CF_5$ using the following equation:

$\Delta CF_i$ = [Δrevenue – Δcosts – Δdepreciation][1 – tax rate] + Δdepreciation
– ΔNWC +/– Salvage or Terminal cash flows

$\Delta CF_1$ = [800,000 – 300,000 – 300,000][1 – 0.4] + 300,000 – 0 = <u>$420,000</u>

$\Delta CF_2$ = [800,000 – 300,000 – 480,000][1 – 0.4] + 480,000 – 0 = <u>$492,000</u>

$\Delta CF_3$ = [800,000 – 300,000 – 288,000][1 – 0.4] + 288,000 – 0 = <u>$415,200</u>

$\Delta CF_4$ = [800,000 – 300,000 – 172,800][1 – 0.4] + 172,800 – 0 = <u>$369,120</u>

Note that $CF_5$ must include the recovery of the $50,000 of NWC, sale of machine for $100,000, and tax payment of $5440 on the sale of the machine.

$\Delta CF_5$ = [800,000 – 300,000 – 172,800][1 – 0.4] + 172,800 – (–50,000) +100,000 – 5440 = <u>$513,680</u>

Now we have estimates of all the project cash flows $CF_1$ through $CF_5$. Using the cost of capital r=11%, we can calculate the NPV.

$$NPV = CF_0 + \frac{CF_1}{(1+r)} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \frac{CF_4}{(1+r)^4} + \frac{CF_5}{(1+r)^5}$$

$$NPV = -1{,}520{,}000 + \frac{420{,}000}{(1+0.11)} + \frac{492{,}000}{(1+0.11)^2} + \frac{415{,}200}{(1+0.11)^3} + \frac{369{,}120}{(1+0.11)^4} + \frac{513{,}680}{(1+0.11)^5} = \$109{,}282$$

**NPV** = **<u>$109,282</u>**, therefore if this is a stand-alone project, it should be accepted. Also, the **<u>IRR=13.7983%</u>**, which is greater than the *hurdle rate* of r=11%.

# <u>IV. Inflation and Capital Budgeting</u>

Here, the term *nominal* refers to the effective annual rate of interest or absolute dollars (not adjusted by inflation into *current* dollars).

Let r=10% per year in capital markets; we call this the nominal rate, as opposed to the *real* rate. Let the expected rate of inflation be π=5% per year.

One widget costs $1 today. Next year it should cost ($1)(1+0.05) = $1.05. The same $1 invested in capital markets today grows to ($1)(1+0.1) = $1.10 next year.

This year you can buy 1 widget with your $1. Invest the dollar for one year in the capital markets instead and next year you can buy $1.10/$1.05 = <u>1.0476</u> widgets. Your purchasing power has increased by 4.76% over the year, and therefore you have earned a *real* interest rate of 4.76% by investing in capital markets.

For any number of periods, you can always convert nominal cash flows to real (t=0 purchasing power) by discounting by the rate of inflation:

$(1+r_{real})^n = (1+r)^n/(1+\pi)^n \quad \rightarrow \quad CF_{0,\, real} = CF_{n,\, nominal}/(1+\pi)^n$

Any future nominal amount of cash can be converted into current or real dollars by discounting it at the inflation rate. For instance, \$400,000 is expected in t=4 years. r=10% and π=5%. This amount in current or real dollars is $400{,}000/(1+0.05)^4$ = \$329,081.

<u>NPV analysis can be done using one of two techniques:</u>

(1) Estimate all future cash flows as *nominal* and then discount the cash flows back to today at the *nominal* cost of capital. This is the most common method and the one we have used so far in this Chapter. Remember to calculate the project's future cash flows with inflation in mind![1]

(2) Estimate all future cash flows as *real* or current dollars and then discount the cash flows back to today at the *real* cost of capital.

If done correctly, the NPV is identical between methods (1) and (2) above. Don't make the mistake of estimating all the cash flows as *current* dollars, and then discount them at the *nominal* rate.

# V. Investments of Unequal Life

## Equivalent Annual Cost (EAC) method:

(1) Find the $PV_0$ of the costs of a machine, and (2) express this PV as an annuity. This method is easier if we use constant or *current* dollars and *real* discount rates. In other words, *inflation* has been removed from all the dollars and discount rates.

**Example:** A machine costs \$12,000 to purchase and costs \$3000 per year to maintain over its 4-year life. The machine can be sold for \$2000 at the end of year 4.[2] All dollar amounts given are in *current* dollars. The *real* cost of capital is r=6% per year. The time line of expected costs is shown below.

| t=0 | t=1 | t=2 | t=3 | t=4 |
|---|---|---|---|---|
| -12,000 | -3000 | -3000 | -3000 | -3000 +2000 = -1000 |

[1] The r=11% cost of capital in the Part III capital budgeting example already accounts for the following: (1) expected inflation, (2) real rate of interest expected on riskless govt. bonds, and (3) the risk premium of the project.

[2] The assumption in this example is that this machine can be replaced at t=4 years with an identical machine, having the same annual costs.

Step 1: Calculate the PV of all these cash flows. Since all of these net cash flows are negative, and hence net *costs*, the minus sign below is dropped for simplicity.

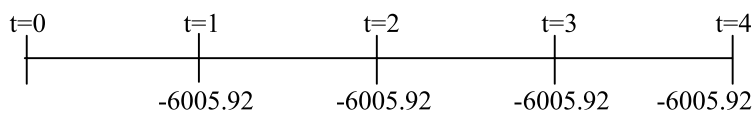
$PV_0 = 12000 + 3000/(1+0.06) + 3000/(1+0.06)^2 + 3000/(1+0.06)^3 + 1000/(1+0.06)^4$

$PV_0 =$ **20,811.13**

Step 2: Express this amount as the $PV_0$ of a 4-year ordinary annuity and calculate the annual cash flow of the annuity.

$$PV_0 = C\left[\frac{1}{r} - \frac{1}{r(1+r)^n}\right] \rightarrow 20811.13 = C\left[\frac{1}{0.06} - \frac{1}{0.06(1+0.06)^4}\right] \rightarrow C = 6005.92$$

This machine has an Equivalent Annual Cost or EAC of **$6005.92**.




What if this machine is being compared to another machine having a life of 8 years and an Equivalent Annual Cost of $6500? The choice is as follows:

We can buy either one 8-year machine or two consecutive 4-year machines, and each choice then provides an operating life of 8 years.

The best choice is to purchase the machine with the *lower* EAC: buy the 4-year life with EAC = $6005.92 and replace it with a similar machine in four years.

If the 8-year machine were to have an EAC < $6005.92, then the 8-year machine would be purchased.

**Decision to replace:**

An existing machine is expected to have the following annual maintenance and salvage values. The machine has five years remaining in its economic life. This machine achieves the same function as the new 4-year machine having an EAC of $6005.92 in prior example. The *real* cost of capital is still r=6%.

When should this existing machine be replaced with the new 4-year machine having EAC=$6005.92? The old machine’s estimated cost/salvage schedule is as follows (assume that maintenance costs occur at year end).

| Year | Maintenance costs | Salvage value |
|---|---|---|
| t=0 (now) | 0 | 8000 |
| t=1 | 4000 | 6000 |
| t=2 | 4500 | 4000 |
| t=3 | 5000 | 2000 |
| t=4 | 5500 | 1000 |
| t=5 | 6000 | 0 |

If the new machine is purchased, then it will have an EAC of $6005.92 with the first EAC amount placed exactly one year from now (t=1 years).

Now find what will be the actual cost of the old machine if left in operation for the following year. If left in operation for one more year, we forego receiving the salvage sale amount of $8000 today, and then at t=1 we pay $4000 maintenance and sell the machine for $6000.

The $PV_0$ of costs of keeping the old machine operating for one more year is:

$PV_0 = 8000 + 4000/(1+0.06) – 6000/(1+0.06) =$ $\underline{\$6113.21}$

The *new* machine's EAC=$6005.92 occurs at t=1 on the time line shown in prior example. To adequately compare the costs of the *old* versus *new* machines, we therefore must convert this old machine's $PV_0$=$6113.21 to its FV at t=1:

$FV_1 = 6113.21(1+0.06) =$ $\underline{\$6480}$. Since this cost of $6480 is *greater* than the new machine's EAC of $6005.02, the old machine should be *immediately* replaced.

(What if) Leaving the old machine in service beyond t=1:

If actually left in service, rather than replaced today, then what would the old machine cost to operate for one additional year beyond t=1. We calculate the costs of operating the machine from t=1 to t=2 years. The salvage value will fall from $6000 to $4000 over this second year.

$PV_1 = 6000 + 4500/(1+0.06) – 4000/(1+0.06) =$ $\underline{\$6471.70}$. Now convert this value to t=2.

$FV_2 = 6471.70(1+0.06) =$ $\underline{\$6860}$. This amount is still higher than the $6005.92 EAC of the new machine. We clearly see that the annual cost of operating the old machine only increases during the second year and thus further underscores why the old machine should be replaced today.