# ***Engineering Economics – Chapter 5***

# **IRR Method: Perceptions and Misconceptions**

For the IRR method, instead of calculating the incremental cash flows, one can find the value of i for which the PVs of the two series are equal. This will give the same result (see graphs).

For example, comparing options 2 and 5 from the previous example:

-1000 + 550 (P/A, i, 3) = -4000 + 1950 (P/A, i, 3)

3000 = 1400 (P/A, i, 3) → (P/A, i, 3) = = 2.1429

(P/A, 18, 3) = 2.1743, (P/A, 20, 3) = 2.1065

 

# Subtleties of ranking options by IRR

This method of selecting the best option is often applied incorrectly. The following **FALSE** reasoning is sometimes used:

(a) Choose the option that gives the highest IRR

Example: In the example, option 2 has the highest IRR = 29.9%. By incorrectly choosing the option with the highest IRR, we lose the chance of investing more of the money at a rate which would also be higher than the MARR (ex. Options 4, 5, 6 and 7).

(b) Choose the option which has the largest initial investment where the IRR is greater than the MARR.

Example: In the example, we would choose option 7 based on this criterion. This decision is wrong also. Although the total investment in option 7 earns 17.3%, the incremental $1000 going from option 5 to option 7 earns –1.3%!!! This incremental investment could have been invested elsewhere at a rate equal to, or greater than, the MARR.

This inconsistency in the approaches can be explained by noting that:

 is generally not equal to 

A table comparing the IRRs and incremental IRRs of several options is useful to practice the application of the IRR method.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **Incremental IRR Compared to plan** | | |
| **PLAN** | **Initial Cost** | **IRR for plan** | **A** | **B** | **C** |
| A  B  C  D | 100,000  175,000  200,000  250,000 | 19%  15%  18%  16% | 9%  17%  12% | 23%  17% | 13% |

# How to determine if there is only 1 IRR

1. Plot the PW profile (over a wide enough range)

2. Perform one of the following tests

(a) Test 1 to ensure only 1 IRR: easy but very restrictive

Let Tt be the net cash flow at period t

(a) F0 < 0

(b) one sign change in the sequence F0, F1, … Fn

(c) PV(0) > 0 ??

This test guarantees a simple profile. However, it is also possible to have a series of cash flows that change sign more than once, and have a standard profile but do not satisfy test 1. That is, test 1 is necessary but not sufficient.

(b) Test 2 to ensure only 1 IRR: harder but more general. Let St be the cumulative cash flow up to and including period T.

Let St be the cumulative cash flow up to and including period t.

(a) S0 < 0

(b) one sign change in sequence F0, F1, … , Fn.

(c) Test 3 to ensure only 1 IRR: harder but best

(a) F0 < 0

(b) Find one rate of return, i\* for the series of cash flows. For that i\*, Ut < 0 for t = 0, 1, 2, … n-1 (Ut is the balance)

N.B. if the first transaction is not negative, the tests can still be used. Ignore transactions of zero, and if the first one is positive, multiply all it them by –1.

## Examples

Recall "JIVE-T" example

|  |  |
| --- | --- |
| **"JIVE-T"** | |
| **Year**  F0 < 0 one sign change  Satisfy test 1 →  only 1 IRR = (13.6%) | **Flow (net)** |
| 0 | -120,000 |
| 1 | 5,000 |
| 2 | 10,000 |
| 3 | 15,000 |
| 4  PBn = PBn-1(1+i) + An  PB: Project Balance  n = period An = Cash flow at n | 20,000 |
| 5 | 25,000 |
| 6 | 30,000 |
| 7 | 35,000 |
| 8 | 40,000 |
| 9 | 45,000 |
| 10 | 55,000 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| MACHINE WITH MAINTENANCE | | | | |
| YEAR | FLOW | **NEG**  **FLOW** | **Ut @ 9.6%** | **Ut @ 0.9%** |
| 0 | 0 |
| 1 | 3000 | -3,000 | -3,000.00 | -3,000.00 |
| 2 | 0 | 0 | -3,288.00 | -4,524.00 |
| 3 | -10,000 | 10,000 | 6,396.35 | 3,177.81 |
| 4 | 2,000 | -2,000 | 5,010.40 | 2,792.14 |
| 5 | 2,000 | -2,000 | 3,491.40 | 2,210.55 |
| 6 | 2,000 | -2,000 | 1,826.57 | 1,333.51 |
| 7 | 2,000 | -2,000 | 1.93 | 10.93 |

Test 1 and 2 not satisfied. Based on test 3, we cannot conclude that there is only ONE IRR, therefore likely several.

Provisions for recovering capital invested in income producing assets are made by charging depreciation against current income.

Depreciation charges are not actual cash flows.

Depreciation charges are introduced in accounting records in order to recover capital invested for production assets and to make deductions from current income allowed by tax laws for tax calculations. The straight-line and declining balance methods are the most commonly used depreciation methods. The straight-line method is designed to account for uniform depreciation, while the declining-balance method is an accelerated method intended to allow for higher depreciation charges earlier in the write-off period. The accelerated charges allowed by tax regulations decrease the time value of taxes.

The tax deduction allowed by regulations for depreciation of an asset is the capital cost allowance (CCA).

**Depreciation and Income Taxes**

Depreciation:

Capital goods deteriorate overtime and we want to account for the deterioration. So as to:

(a) have an accurate evaluation of the value of the goods in the company

(b) calculate tax savings due to loss in value of the equipment.

When capital equipment (also known as fixed assets) is purchased, the expenditure need not be shown as a "loss", since it is, in effect, only an exchange of money for goods. The real loss occurs as the equipment deteriorates over time. So this loss is amortized over the life of the equipment: this is called depreciation.

As well, the government allows a deduction of this loss of value from our revenue before calculating taxes. However, the taxes rules specify how this deduction must be calculated depending on the type of good and other considerations.

Financial Reports:

There are two types of reports that are essential for all business:

(a) balance sheet: shows all of the assets and liabilities of a company at a given time.

(b) income statement: summary of the transactions (revenues and expenditures) in the period between two balance statements.

The calculation of taxes is shown on the income statement so this is where the depreciation must be accounted for.

Example: If there is a depreciation expense of $1000, the cash flow is improved by i\* $1,000 where t is the income tax rate. Consider the following case where t = 40%.

|  |  |  |  |
| --- | --- | --- | --- |
| **Company ZZ – Income Statement – December 31, 19xx** | | | |
| Item | Without Depreciation | With Depreciation | Notes |
| Revenue  Expenses  Operating Expenses  Overhead  Depreciation  Net Profit (before taxes)  Income Taxes | 10,000  4,000  6,000  2,000  0  4,000  1,600  2,400 | 10,000  4,000  6,000  2,000  1,000  3,000  1,200  1,800 | Depreciation is **NOT** an expense  t = 40% |
| Depreciation  Net Cash Flow  Tax Savings | 0  2,400 | 0  2,400  400 | This section is not part of the income statement  Difference of $1000 times t |

N.B. the depreciation is added back in at the end to demonstrate its effect on after-tax cash flows.

Valuation of goods: The value of capital equipment at a particular time can be measured by its market (or salvage) value, or by its calculated depreciation. for accounting purposes, the depreciated value is called the book value, and for tax purposes it is called Undepreciated Capital Cost (UCC). The depreciation is applied to the cost base, which includes all costs attributed to the asset acquisition, including purchase price, shipping, sales tax, installation, and training.

Depreciation Formulae:

There are several ways to calculate depreciation, and some better reflect the actual value of the equipment than others. Various methods are used for accounting purposes, and only a few of the following methods apply to tax depreciation, as specified by the government.

Example: (to illustrate the methods below): A machine which fabricates bearings costs $21,000, and has a salvage value of $1,000 at the end of its 5 year service life.

BV(n) = book value shown on accounting records at the end of year n (adjusted basis); BV(0) = P

DC(n) =  BV(n) = 

P = Purchase price

S = Salvage value or future value at the end of the assets useful (tax) life

N = useful (tax) life of asset

n = number of years of depreciation or use from time of purchase

DC(n) = annual charge for depreciation in year n

A. Straight-line Depreciation: value of the equipment declines linearly with time

depreciation - 

Example: 

B. Units-of-production: the equipment loses value proportionally to the number of pieces fabricated.

Example: Suppose that the bearing-making machine can produce 200,000 bearings before being completely worn out. Also, say that 35,000 bearings can be produced in the first year of operation.

depreciation (in year 1) = 

C. Sum-of-the-years-digits (SOYD): the depreciation in a given year is found by multiplying the initial cost base by a fraction where the numerator is the expected remaining years of service (including the year for which the depreciation is calculated), and the denominator is the sum of the digits of the total years of service.

Example: Sum of the years: 1 + 2 + 3 + 4 + 5 = 15 (general formula: N \*(N+1)/2 for service life N)



First Year: Depreciation: 

Book value after 1 year: $21,000 - $6,667 = $14,333

Second Year: Depreciation: 

Book value after 1 year: $14,333 - $5,333 = 9,000

B(n) = D – (D1 + D2 + . . . + Dn) B(n) = D(n-1) – D(n)

This method is particularly useful when the equipment wears out more in the early years, then subsequently.

D. Declining Balance (DB) Methods: The depreciation rate is a fixed percentage d of the undepreciated value of the equipment at the start of the year.

For accounting purposes, the rate may be estimated by d = 1/N where N is the service life. Another variant, used a lot in the U.S., is double declining balance method (DDB) where d = 2/N. For Canadian Tax purposes, the government sets d for various classes of goods.

Example: Suppose that the DB rate for the bearing-making machine is 20% per year.

|  |  |  |
| --- | --- | --- |
| **Year** | **Depreciation** | **Book Value** |
| 0  1  2  3  etc | 0.20 x $21,000 = $4,200  0.20 x $16,800 = $3,360  0.20 x $13,440 = $2,688  etc | $21,000  $16,800  $13,440  $10,752  etc |

Notes: - for the Declining Balance Methods, the book value never reaches zero (in theory).

- in general, the book value is never equal to the salvage value B(n) = B(n-1) – D(n)

To make BVN = SVN, there are 2 cases (see examples in the text):

(a) BV would fall below SV before year N: simply set the depreciation in that year so that BV = SV and do not depreciate any further.

(b) BV won't reach SV by year N: in the year where depreciation calculated by DB is less than that calculated by the straight line (SL), switch to the straight line until year N, this will permit BV to equal SV in year N.

**Canadian Income Tax Depreciation Rates:**

– the government categorizes goods into classes, then specifies the depreciation rate for each class. Most classes depreciate using DB, and a few are SL.

– terminology for tax purposes:

CCAn: Capital Cost Allowance (allowable depreciation in year n)

UCCn: Undepreciated Capital Cost (Book value at the end of year n)

A. Sample of CCA rates

CCA RATES: DECLINING BALANCE CLASSES

Class 3, CCA rate = 5% - buildings made of brick, stone or concrete

Class 6, CCA rate = 10% - other buildings

Class 7, CCA rate = 15% - ships, boats, etc

Class 8, CCA rate = 20% - machinery and equipment not included in other classes

Class 10, CCA rate = 30% - cars, trucks, etc

CCA RATES: STRAIGHT LINES CLASSES

Classes 13 and 14, CCA rate over the life of the asset – leasehold improvements; patents, licenses, franchises, etc.

Classes 24 and 29, CCA rate = 50% - water pollution control equipment; certain machinery used in the manufacture or processing of goods.

Asset Classes

Each piece of equipment is not depreciated individually, but rather its value is added to the existing UCC or other items of the same class. Then the entire class is depreciated at the end of the year.

The CCAk in year k is given by (where d is the CCA rate for the corresponding asset class):

(i) for new equipment: CCAk = (UCCk-a + ½ purchasesk – salesk) d

(ii) for existing equipment: CCAk = (UCCk + purchasesk – salesk)d

Half-Year Rule

Only HALF of the allowable CCA for new equipment may be applied in the year that it is purchased.

In both cases above, the UCCk at the end of year k is given by:

UCCk = UCCk + purchasesk – salesk - CCAk

Example: For the following company: show the UCC and CCA every year.

- at the start of 1991, a company owns several vehicles with a total UCC of $120,000

- during 1991, the number of vehicles does not change.

- purchase of a new truck during 1992 (for $20,000)

- sale of an old care in 1993 (for $8,000)

Solution:

- vehicles are in class 10 (CCA rate 30%) (see text, Fig. 7.8 for actual Revenue Canada CCA form)

|  |
| --- |
| 1990 UCC1990 (Balance at the end of 1990) $120,000 |
| 1991 CCA1991 for 1991 (@ 30%) (0.30\*120,000) -$36,000+  UCC1991 $84,000 |
| 1992 Purchases during 1992 $20,000  CCA1992 = 0.30\*(84,000 + 20000/2) -$28,200++  UCC1992 $75,800 |
| 1993 Sales during 1993 -$ 8,000  CCA1993 = 0.3\*(75,800 – 8000) -$20,340  UCC1993 $47,460 |

++ tax savings are based on these amounts

OTHER CONSIDERATIONS FOR ESTABLISHING CCA:

• Available-for-use rule: earliest of first used or CAN be used, or just prior to disposal

• Claim UP TO maximum allowable CCA

• Terminal Loss (no other property in class) (i.e., SV < UCC): treat as deduction from income

• Capital Gains (i.e., SV > purchase price): taxed on the difference at the capital gains tax rate

• Recaptured CCA (when SV > UCC): difference added to income

• Additional or Improvements to Depreciable Assets (i.e., increase value and/or life): add cost to UCC

• Depletion allowance for mineral properties: treat like depreciable asset with many special rules.

Income Tax: CCTF and disposal effects

Disposal effects: gains or losses associated with the sale of depreciable assets.

On an annual basis, dealing with the tax depreciation of equipment is fairly straight forward, as demonstrated in Chapter 7, 8, 9 of the text. Each year, the tax schedule is filled out, showing the Undepreciated Capital Cost (UCC) in each class at the start of the year, adding new purchases (then adjusting for the ½ year rule for new assets), subtracting sales and calculating the end-of-year UCC.

However, when it comes to analyzing the tax effects of a single investment or project, the cumulative effect of the Capital Cost Allowance (CCA) over several years must be calculated.

Given the cost base of P as the original acquisition cost, and a CCA rate of d (depending on the asset class), if the asset is depreciated "forever", the CCA for each year can be calculated as follows:

Year 1: CCA1 = ½ Pd (due to half-year rule)

Year n: CCAn = Pd (1 – ½ d)(1 – d)n-2 for n = 2, … N.P.T.O.

Sn = a + ar + ar2 + … 4 arn-1 (1)

multiply (1) by r → rSn  = ar + ar2 + ar3 + … + arn (2)

(2) – (1) → rSn – Sn = arn – a → Sn = a(rn-1)/(r – 1 ) = a(1 – rn)/(1 – r)

If the whole CCA is claimed in EVERY year, and if sufficient revenues are generated in every year so that the full tax benefit (or Tax Shield) is realized by deducting the CCA every year, then the savings in year n are tCCAn where t is the marginal tax rate. Therefore, the Present Value of the CCA tax savings "forever" is

PVtax-shield = tCCA1 (P/F, i, 1) + tCCA2 (P/F, i, 2) + … + tCCAn (P/F, i, n)

PVtax-shield = 

PVtax-shield = 

 (1)

The PV net cost of the asset is therefore the acquisition cost less the PV of depreciation tax savings:

PVacquisition =  (2)

Sn = 

The expression in the parenthesis is called the Capital Cost Tax Factor (CCTF). It is a commonly used term which reflects the effective fraction reduction in investment cost due to tax depreciation.

Salvage Value

If the asset is sold for SN in year N, this amount gets subtracted from the Undepreciated Capital Cost (UCC) at the end of the year, so that CCA is "lost" from then on, compared to the above "infinite" estimate in equation (1) as follows:

"lost" CCA:

 (3)

The present value of this "loss" of tax shield from selling the asset is:

PVlost shield =  (4)

The net effect, including tax depreciation of purchasing and then selling an asset, is therefore:

 (5)

This expression is exact, given the assumptions made throughout this derivation.

Comparison of tax shield approach vs tabular approach

Consider equations (2) and (4). If the asset is worth BN on the books at the end of year N, and we sell it for SN in that year, then viewed from the end of the year N, the PV of the tax shield that we would have had is:  whereas the PV of the shield lost from selling it is: . The PV adjustment to the tax shield viewed from year N is therefore: .

Despite the fact that these tax savings are discounted for over several years, if the time value of money is ignored (i.e., i = 0), then the expression simplifies to : t(BN – SN). The textbook suggests this as a simplified version of the tax shield adjustment to be entered in year N of the income statement when an asset is sold in year N.

Net Present Value after-tax:

If the operating profit every year from this new project is Rn, then t percent of this is lost due to income tax, and the after-tax. PV of the project is:



Example on: After-tax Evaluation of a Depreciable Asset

The budget includes $45,000 for the purchase of a new testing machine requested by the maintenance department. All the major investment in the budget are being checked to see if the required rate of return of 15 percent after taxes can be achieved. The testing machine is 20 percent CCA declining-balance class. Over 6 years, it is estimated to save $23,000 per year in maintenance costs with annual operating costs being $7,300. It will be depreciated by the declining-balance method and have no salvage value. The firm has an effective composite income tax rate of 40 percent. Does the proposal to buy the testing machine satisfy the firm's new acceptable rate of return?

Solution

PW = $45,000 + ($23,000 - $7,300)(P/A, i\*, 6) = 0 **[?]**

45,000 = 15,700  → 2.8662 i\*(1 + i\*)6 = (1 + i\*) –1

Let 1 + i\* = X

→ 2.8662 (x-1) X6 = X6 – 1 → 2.8662X7 – 3.8662X6 + 1 = 0

→ Before-tax IRR = 26.3 percent. Thus, IRRafter-tax = (26.3%)(1-0.40) = 15.8% > MARR

After-tax computations are based on the table below. The depreciation charges result form applying the CCA rate of 20 percent and the half-year rule.

Cash flow diagram

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Investment**  **Year**  **(1)** | **Before-tax**  **Cash Flow**  **(2)** | **Depreciation**  **Charge**  **(5)** | **Taxable**  **Income**  **(9)=(2)+(5)** | **Taxes**  **(40%)(9)=10** | **After-tax**  **Cash flow**  **(11)=(2)-(10)** |
| 0  1  2  3  4  5  6  6  6 | -$45,000  $15,700  $15,700  $15,700  $15,700  $15,700  $15,700  0 Salvage  Disposal tax-effect | $4,500.00  $8,100.00  $6,480.00  $5,184.00  $4,147.20  $3,317.76 | $11,200.00  $ 7,600.00  $ 9,220.00  $10,516.00  $11,552.80  $14,382.24 | $4,480.00  $3,040.00  $3,688.00  $4,205.40  $4,621.12  $4,952.90 | -$45,000.00  $11,220.00  $12,660.00  $12,012.00  $11,493.60  $11,078.88  $10,747.10  [$13,271.04] x [td/(i+d)] |

The best value or undeprecated capital cost (UCC) at the end of the sixth year = $45,000 - $31,728.96 (sum of depreciation changes) = $13,271.04

Since the salvage value = 0, tax shield adjustment applies PW of tax adjustment = (P/F, i, 6)(UCC – salvage) x [td/(i + d)].

Here, t = 0.4 or 40%, d = 0.2 or 20%.

Utilizing the after-tax cash flow data in column 11 of the table above and the tax shield adjustment, we find that the present-worth formula for calculating the rate of return is as shown below:

PW = -$45,000 + ($11,220)(P/F, i, 1) + ($12,600)(P/F, i, 2) + ($12,012)(P/F, i., 3) + ($11,493.60)(P/F, i, 4) + ($11,078.88)(P/F, i, 5) + ($10,747.10)(P/F, i, 6) + PW of tax shield adjustment.

The present worth of this alternative at the MARR of 15% is $219.42.

At i = 15%, PW = -$1023.33

So, IRRafter-tax can be found as 15% + 1% [($219.42)/[$219.42 – (– $1023.33)] = 15.18%

The proposal apparently meets the after-tax rate-of-return criterion.

Several features of the table above merit review. The before-tax cash flow in column 2 corresponds to the cash flow diagram displayed in the solution. A comparable after-tax cash flow diagram, represented in column 11, is the one on which the calculations are based. The deprecation charges in column 5 do not represent a cash flow, they are shown only to accommodate the calculations of income taxes.

After-Tax Economic Comparisons

IRRafter-tax = (IRRbefore-tax)(1- effective tax rate)

After-tax Analysis including debt financing

Corporations may pay interest on borrowed funds and receive interest (called earned interest) on investments. Interest paid on borrowed funds is deductible form revenue in determining taxable income. This deduction is, in effect, a government subsidy and, as such, reduces the cost of the loan. Corporations can borrow funds in two ways. First, through issuing bonds in which case only the interest in repaid periodically and the principal is repaid at the end of the life of the loan. Second, through a mortgage in which case both principal and interest are repaid periodically throughout the life of the loan.

Example on: After-Tax Evaluation when Investment capital is borrowed

A firm with a effective income tax rate of 42 percent is interested in purchasing a new machine for $45,000. In order to pay for this asset, the firm acquired a $20,000 debt at 10 percent interest, with interest to be paid annually and principal to be paid at the end. The remaining $25,000 is from the firm's equity capital. The minimum attractive rate of return is 12 percent (after tax). The useful life of this asset is 5 years, with a zero salvage value after 5 years. Income (estimated to result due to machine) is $23,000/year and annual operating expenses are estimated to be $7,300/year. This results in net income of ($23,000-$7,300) = $15,700). The machine is in class 8 (20 percent CCA rate, declining – balance class). The investor wishes to find the present worth of after-tax cash flow and therefore to establish the feasibility of the project.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year**  **(1)** | **Before-tax**  **Cash Flow**  **(2)** | **CCA**  **(5)** | **Interest**  **Charges**  **(8)** | **Taxable**  **Income**  **(9)** | **Taxes @ 42%**  **(10)** | **After-tax**  **Cash flow**  **(11)** |
| 0  1  2  3  4  5  5 | -$45,000  $20,000  $15,700  $15,700  $15,700  $15,700  $15,700 | $4,500.00  $8,100.00  $6,480.00  $5,184.00  $4,147.20 | $2,000  $2,000  $2,000  $2,000  $2,000 | $9,200.00  $5,600.00  $7,220.00  $8,516.00  $9,552.80 | $3,864.00  $2,352.00  $3,032.40  $3,576.72  $9,552.18 | -$45,000.00  $20,000.00  $ 9,835.00  $11,348.00  $10,667.60  $10,123.28  $ 9,687.82  -$20,000.00 |

Interest charge/year = debt x interest rate = $20,000 x 0.1 = $2,000/year

CCA for Year 1 = $45,000 (0.2/2) = $4,500

CCA for Year 2 = [$45,000 - $4,500](0.2) = $8,100

CCA for Year 3 = [$45,000 – ($4,500 + $8,100)](0.2) = $6,480

CCA for Year 4 = [$45,000 – ($4,500 + $8,100 + $6,480)](0.2) = $5,184

CCA for Year 5 = [$45,000 – ($4,500 + $8,100 + $6,480 + $5,184)](0.2) = $4,147.20

Sum of depreciation or CCA for years 1 to 5 = $28,411.20

Book value at the end of year 5 = Undepreciated Capital Cost (UCC)

= ($45,000 – $28,411.20) = $16,588.80

PW(12%)after-tax = –$45,000 + $20,000 + $9,836 (P/F, 12, 1) + $11,348(P/F, 12, 2) + $10,667.60 (P/F, 12, 3)

+ $10,123.28 (P/F, 12, 4) + $9,587.22 (P/F, 12, 5) – $20,000 (P/F, 12, 5)

= –$45,000 + $20,000 + $9,836 (0.8929) + $11,348(0.7922) + $10,667.60 (0.7118)

+ $10,123.28 (0.6355) + $9,587.22 (0.5874) – $20,000 (0.5674)

= $1,004.26

Present worth of tax shield adjustment = (P/F, 12, 5) [book value – salvage] x [td/(i+d)]

Book value = Undepreciated Capital Cost (UCC) = $16,588.80 (see above)

Salvage = $0, t = 0.42, d = 0.2, i = 0.12

PWtax-shield adjustment = (0.5674)($15,588.80 – 0)[(0.42)(0.2)/(0.12 + 0.2)] = $2,470.77

PWtotal = PWafter-tax + PWtax-shield adjustment = $1,004.26 + $2,470.77 = $3,475.03 (feasible!!)

Alternatively,

The capital cost tax factor (CCTF) (half-year rule) = 1 – tax shield



PWtotal = -($45,000 of investment)(0.752) + ($20,000 debt) + (1 – tax rate)($23,000 - $7,300 - $2,000)(P/A, 12, 5)

– ($20,000 of principal repayment)(P/F, 12, 5)

= -$45,000(0.752) + $20,000 + (1-0.42)($13,700)(3.6048) - $20,000(0.5674) = $3,455.74 (feasible!!)

The difference between the two answers is due to the approximate nature of the second approach.

Example: Suppose a machine, in class 29 (CAA rate of 50 percent straight-line class), costs $45,000 initially and has no salvage value after 5 years of use. During the 5 years, it is estimated to save $23,000 per year in maintenance costs while its annual operation costs are $7,300. The MARR is 12 percent after taxes and the firm has an effective income tax rate of 42 percent.

(a) Should the machine be bought? Apply the half-year rule.

(b) On the assumption that the half-year rule does not apply, find the after-tax present worth.

Solution: CCA Tax Shield (Tax Savings/Deductions): Straight-line Class

Assumed investment: $1 ; The CCA rate (depreciation) = d% ; Years required for full depreciation = k

Under the half-year rule: k = [(100%)/(d%)] + 1 round to lower number. If half-year rule is not applicable: k = [(100%)/(d%)] round to higher number.

(a) The half-year rule applies and therefore the tax shields due to straight-line CCA are 25%, 50 percent and 25% in year 1, year 2 and year 3 respectively.

The PW of CCA tax shields for $1 invested in Class 29 is:

PWtax-shields = CCA, t (P/F, i, 1) + CCA2 t (P/F, i, 2) + CCA3t (P/F, i, 3)

PWtax-shields = 

When half-year rule is not applicable, the depreciation pattern is as follows (sum of d's equal 1):

Years 1 2 . . . k

Depreciation d d . . . d



Tax Shield (in PW) = td (P/A, i, k)

If the half-year rule is applicable, then the depreciation pattern is ( of d's = 1):

Years 1 2 . . . k

Depreciation d/2 d . . . d/2

Tax Shield (in PW) = 

The CCTF then becomes

CCTF = 1 – t (0.5) d(1 + i)(P/A, i, 2)2 = 1 – (0.42)(0.5)(1 + 0.12)(1.6901)2 = 0.664

PWafter-tax = (-$45,000)(CCTF) + (1 – 0.42)($23,000 - $7,300) (P/A, 12, 5)

(0.664) (3.6048)

= -$29,880 + $32,825 = $2,945

(b) Since the half-year rule does not apply, the present worth of tax shields

= (PW of Year 1 shield) + (PW of Year 2 shield)



The CCTF then becomes

CCTF = 1 – td(P/A, 12, 2) = 1 – (0.42)(0.5)(1.6901) = 0.645

PWafter-tax = (-$45,000)(CCTF) + (1 – 0.42)($23,000 - $7,300) (P/A, 12, 5)

(0.645) (3.6048)

= -$29,025 + $32,825 = $3,800

In this case the simulative effect of accelerated CCA is higher than in part (a). In part (a) the half-year rule reduces the PW by: ($3,800 - $2,945) = $855). The percentage reduction in the incentive is $855.

# Example (9.7): A firm has been paying a print shop $14,000 annually to print the company's monthly newsletter. The agreement with this print shop has now expired but could be renewed for another 5 years. The new subcontract charges are expected to be 10% higher than what they were in the previous contract. The company is also considering the purchase of a desk top publishing system with a high-quality laser printer driven by a microcomputer. With an appropriate word/graphics software, the newsletter can be composited and printed in near typeset quality. A special device is also required to print photos on the computer vendor:

Microcomputer $ 5,500

Laser Printer $ 8,500

Photo device/scanner $10,000

Software $ 2,000

Total Cost base $26,000

Annual O & M costs $10,000

At the end of 5 years, each equipment piece is expected to retain only 10% of its original cost in salvage value. The company's marginal tax rate is 40%, and the desktop publishing system will be depreciated as CCA class 10 property. (i.e., 30% CCA rate)

(a) Determine the projected net after-tax cash flows for this investment.

(b) Compute the IRR for the project.

(c) Is the project acceptable at MARR = 12%?

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Years** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Income Statement** | | | | | | |
| ***Revenues*** |  | $15,400 | $15,400 | $15,400 | $15,400 | $15,400 |
| ***Expenses*** |  |  |  |  |  |  |
| *Operating Costs* |  | $10,000 | $10,000 | $10,000 | $10,000 | $10,000 |
| *CCA* |  | $3,900 | $6,630 | $4,641 | $3,249 | $2,274 |
| *Taxable Income* |  | $1,500 | ($1,280) | $759 | $2,151 | $3,126 |
| *Income Taxes* |  | $600 | ($492) | $304 | $860 | $1,250 |
| *Net Income* |  | $900 | ($738) | $455 | $1,291 | $1,876 |
| **Cash Flow Statement** | | | | | | |
| ***Cash from Operations*** |  |  |  |  |  |  |
| *Net Income* |  | $900 | ($738) | $455 | $1,291 | $1,876 |
| *CCA* |  | $3,900 | $6,630 | $4,641 | $3,249 | $2,274 |
| *Investment/Salvage* | ($26,000) |  |  |  |  | $2,600 |
| *Disposal tax effect* |  |  |  |  |  | $1,082 |
| *Net Cash Flow* | ($26,000) | $4,800 | $5,892 | $5,096 | $4,540 | $7,832 |

-26,000 + 4,800 (P/F, i, 1) + 5,892 (P/F, i, 2) + 4,096 (P/F, i, 3) + 4,540 (P/F, i, 4) + 7,832 (P/F, i, 5) = 0



26,000 (1 + i)5 = 4800 (1 + i)4 + 5892 (1 + i)3 + 5,096 (1 + i)2 + 4,540 (1 + i) + 7832

let 1 + i = X

26 X5 = 4.8 X4 + 5.892 X3 + 5.096 X2 + 4.54 X + 7.832

26 X5 - 4.8 X4 - 5.892 X3 - 5.096 X2 - 4.54 X - 7.832 = 0

Let X = 1.15 → R = 15.15

X = 1.12 R = 11.09

X = 1.05 → R = 2.31

X = 1.025 → R = -0.066

X = 1.0 R = -2.16

X = 1.03 → R = 0.385

X = 1.0258 → R = 0.0053

X = 1.02575 → R = 0.0008609

IRR = 2.575%

IRR < MARR → not acceptable

CCA Recapture

Should a depreciable asset be sold after its use for an amount greater than its initial cost, there are two types of gains that are applicable. The first is the capital gain, which results when the sale price of an asset is greater than the purchase price. [capital gains = (sale price – purchase price)]. The second gain is the depreciation claimed by the firm, equal to the difference between the original purchase and the book value, termed the recaptured depreciation or CCA recapture. The CCA recapture is taxable. While the capital gains are taxed at a capital gain tax rate, the recaptured depreciation is taxed at the ordinary income tax rate. The current tax law allows a special lower rate of taxation for capital gains.

Therefore: Disposal tax effect = capital gains tax + tax on recaptured depreciation

= (salvage value – original purchase price)(capital gain tax rate)

+ (original purchase price – book value)(tax rate)

Generally, a depreciable asset may be sold below the original purchase price. In such a case, we are interested in finding out whether the salvage income is above, equal to, or below the book value of the asset. The salvage value represents the proceeds from the sale minus any selling expense or removal costs. In order to establish what type of disposal tax effect has to be applied, we have to calculate the book value or undepreciated capital cost at the time of disposal of the asset.

If the sale price is higher than the undepreciated capital cost (UCC) or book value, CCA recapture applies. The recapture depreciation or recaptured CCA for declining-balance class as well as straight-line class is taxable.

That is: Tax effect = (sale price – UCC) x t where t is the tax rate

It should be noted that here income from disposal of the asset or sale price is less than the original purchase price. Furthermore, if (UCC – sale price or salvage) is 0, both tax shield adjustment and CCA recapture are equal to 0.

Example on: Capital Gain and CCA Recapture The purchase price of a class 8 asset bought 5 years ago was $50,000. The sale price was $60,000 and the effective tax rate was 46 percent. The class 8 CCA rate was 20 percent (declining – balance method class). Fine the capital gain and CCA recapture, if applicable.

UCCk = UCCk-1 – CCAk = UCCk-1 – UCCk-1 d = UCCk-1(1-d)

UCC1 = UCC0(1-d/2)

UCC2 = UCC1(1-d) = UCC0(1-d/2)(1-d)2

UCC3 = UCC2(1-d) = UCC0(1-d/2)(1-d)2

UCC4 = UCC5(1-d) = UCC0(1-d/2)(1-d)3

UCC5 = UCC4(1-d) = UCC0(1-d/2)(1-d)4

Solution:

Capital gain = ($60,000 - $50,000) = $10,000

Assumed tax rate for capital gain = ½ (effective tax rate)

(¾)

Capital gain tax = ½ (0.46)($10,000) = $2,300

= (¾) = ($3,450)

Undepreciated Capital Cost (UCC) or book value after 5 years of use (half-year rule):

UCC = $50,000 (0.5)(1 – CCA rate of 0.2)4 + $50,000 (0.5)(1 – CCA rate of 0.2)

= $10,240 + $8,189 = $18,429

UCC5 = UCC0(1-d/2)(1-d)4 = 450,000 (1 – 0.2/2)(1 – 0.2)4 = $18,432

UCC = 50,000 -  UCCk = (UCCk-1 + salesk + purchasesk)d = UCCk-1 d

UCCk = UCCk-1 - CCAk

UCC1 = UCC0 – CCA1 = $50,000 – ½ (0.2)($50,000) = $45,000

UCC2 = UCC1 – CCA2 = $45,000 – (0.2)($45,000) = $36,000

UCC1 = UCC2 – CCA3 = $36,000 – (0.2)($36,000) = $28,800

UCC1 = UCC3 – CCA4 = $28,800 – (0.2)($28,800) = $23,040

UCC5 = UCC4 – CCA5 = $23,040 – (0.2)($23,040) = $18,432

CCArecapture = (purchase price – UCC) x (tax rate)

CCArecapture = ($50,000 - $18,432) x (0.46) = $14,521.28

Total tax = $2300 + $14,521.28 = $15,821.28

($3,450) ($17,971.28)

Example on: Disposal Tax Effect on Depreciable Assets (CCA = 30% with declining balance) A class 38 power-operated movable piece of equipment was bought by a company for $200,000. Find the disposal tax effects under the following assumptions of salvage value after 3 years of service: (a) $200,000; (b) $220,000. The company's tax rate is 40 percent. Assume that the capital gains are taxed at only ¾ of the Company's normal rate (i.e., 0.75 x 40% = 30%). Find the disposal tax effects and the net salvage value.

Solution

The undepreciated capital cost after three years of service can be calculated from the given information:

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Capital Cost Allowance**  **CCA = 30%** | **Book Value at the**  **end of the Year** | + The CCA for Year 1  reflects the half-year rule |
| 0  1  2  3 | $30,000+  $51,000  $35,700 | $200,000  $170,000  $119,000  $83,300 |

UCC3 = UCC0 (1 – d/2)(1 – d)2 = $200,000 (1 – 0.3/2)(1 – 0.3)2 = $83,300

(a) The sale price is $200,000, which is the same as the purchase price. Therefore, there is no capital gain. On the other hand, CCA recapture is applicable since the sale price is higher than the book value.

CCArecapture = (salvage – UCC)(tax rate) = ($200,000 - $83,300)(0.4) = $46,680

Net Salvage value after disposal tax = ($200,000 - $46,680) = $153,320

(b) Since the sale price of $220,000 is higher than the purchase price of $200,000, the capital gains tax has to be paid. Additionally, the CCA recapture applies.

The capital gains tax = ($220,000 - $200,000)(0.3) = $6,000. The CCA recapture was found in part (a) to be $46,680. Therefore total disposal tax is = $6,000 + $46,800 = $52,680. Salvage value after disposal tax = ($220,000 - $52,680) = $167,320.

**INFLATION**

Definition: general increase in the prices of all goods (note that individual prices rise at different rates)

Measures of Inflation: Several indices have been developed. some common ones are:

(1) General price index: goods and services within an economy

(2) Wholesale price index: rise in wholesale prices

(3) Consumer price index (CPI): CPIyear n = 

where the "basket" is for a typical family

Other indices

ISPI: Industrial Selling Price Index – measure inflation at the wholesale level for both consumer and industrial goods but not services.

IPI: Implicit Price Index – measures the effect of general price-level changes on the Gross National Produce (GNP)

IPPI: Industrial Product Price Index

RMPI: Raw Materials Price Index

Inflation rate: (based on CPI)

For 1 year 

Example: 

For k years: 

History of CPI: (CPI is arbitrarily set to 100 in chosen base year.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **BASE YEAR** | | | |  | **Average Inflation Rate** | |
|  | 1949 | 1961 | 1971 | 1981 |  | 1949 – 1961 | 2.15% |
| 1949 | 100 |  |  |  |  | 1961 – 1971 | 2.89% |
| 1961 | 129 | 100 |  |  |  | 1971 – 1981 | 9.00% |
| 1971 | 172 | 133 | 100 |  |  | 1981 – 1991 | 5.26% |
| 1981 | 406 | 315 | 237 | 100 |  | 1949 – 1991 | 4.66% |
| 1991 | 678 | 526 | 395 | 167 |  |  |  |

When money is generated at a faster rate than the growth in goods and services, it is subject to the old economic law that the more there is of something, the cheaper it becomes. In the case of money, cheaper means it losses purchasing power.

Other causes of inflation:

• Cost-push inflation – this represents increases in producer costs that are passed along to customers, sometimes with disproportionate escalations that push prices up.

• Demand-pull inflation – excessive spending power of consumers, sometimes obtained at the expense of savings, that pulls prices up.

• Impact of international forces on prices and markets – e.g. escalation of energy prices.

• Unresponsive prices that seldom decline – regardless of market conditions, because wages set by union contracts and prices set by some very large firms almost never fall.

• Inflation psychology – that leads consumers to "buy ahead", often on easily obtained credit, in the belief that prices will inevitably inflate and loans can be repaid in cheaper dollars.