**FOR FIN 4310 MANAGERIAL FINANCE**

**LECTURE 8**

***FINANCIAL ANALYSIS, CORPORATE VALUATION AND CAPITAL FORMATION***

by

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**LECTURE 8 CAPITAL FORMATION OR BUDGETING II**

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**Special Handout: Multiple Internal Rates of Return**

**8.1. Introduction**[[1]](#footnote-1)

The traditional approach discussed above for a single project clearly requires just an up or down decision regarding the project – accept or reject. When more than one project is considered, however, a ranking of acceptable projects is necessary when, although economically independent and acceptable, they cannot all be accepted because of internal or external rationing. Or when acceptable projects are mutually exclusive (perfect substitutes), because in this case only one project can be accepted.

Projects are economically independent when it is technically possible to undertake one with or without the other, and the benefits associated with one are not affected by the second. In this case, even though two independent projects may be acceptable, it may be that the firm can only finance one because of capital rationing. Internal capital rationing occurs when the firm, possibly due to high risk aversion, sets a higher cutoff rate than the market’s cost of capital. In this case, projects are accepted only when its net present values are positive or its internal rates of return are higher given the firm’s self-imposed higher discount rate. Alternatively, for internal capital rationing, the firm may simply be unwilling to finance all acceptable projects. In contrast, external capital rationing is imposed on the firm by the financial markets via differing borrowing and lending rates. As such, a firm may prefer to lend rather than borrow to finance a project, because the project’s net present value may be less than zero when it borrows but greater than zero when it lends. In either case, when capital rationing exists, ranking of acceptable projects is necessary to determine which will be rationed out.

Projects are mutually exclusive when they are economically dependent and perfect substitutes. Economically dependent projects exist when the cash outlays and inflows for one are not the same when another is accepted compared to when it is rejected. Generically, projects are *complements* (a soccer stadium with a parking lot in Brazil) when the benefits expected from the first increase if the second is undertaken. They are *substitutes* (such as a toll bridge and ferry-boat service across the Bosphorous in Istanbul) when the benefits expected from the first decrease if the second is undertaken. Projects that are *mutually exclusive* (an apartment complex versus office building on a given parcel of land in Singapore) are either perfect substitutes, such that the benefits expected from one disappear if the second is undertaken, or it is technically impossible to make both investments simultaneously. In this case, ranking of acceptable projects is also necessary because not all such projects can be undertaken.

A need to rank acceptable projects complicates the capital budgeting decision, because not all of the criteria that can be used (such as net present value and internal rate of return) produce the same ranking. In general, the ranking obtained from NPV is best, but the use of IRR in corporate finance is more popular. In the latter case, the IRR calculation is modified in a conceptually appropriate way, and it turns out that such ranking provides the same order for acceptable projects as the NPV. A variety of problems peculiar to the capital budgeting decision and methods to address them are discussed below.

## **8.2.1. Mutually Exclusive Projects I**

Imagine that mutually exclusive projects A and B are both 3-year projects in Scotland with Scottish pound cash flow patterns in time periods 0, 1, 2 and 3 as shown below.

Period 0 Period 1 Period 2 Period 3

Project A -£20,000 £ 5,000 £10,000 £25,000

Project B -£20,000 £15,000 £10,000 £ 5,000

The appropriate discount rate for both projects is 5%. Using only the internal rate of return criteria, we can determine which of these two projects should be accepted, by performing an appropriate marginal analysis.

Project A’s IRR is 33.11 percent and Project B’s IRR is 28.86 percent; by this ranking, A should be chosen over B. However, A produces more non-discounted cash flows than B (£40,000 compared to £30,000), although A’s cash flows arrive later in time than B’s. The timing differences between A and B can result in ranking errors using the IRR, because of the reinvestment rate requirements on the cash flows. Hence, it is necessary (when using IRR) to perform a marginal analysis as follows.

Period 0 Period 1 Period 2 Period 3

Project A -£20,000 £ 5,000 £10,000 £25,000

Project B -£20,000 £15,000 £10,000 £ 5,000

B – A £-0- +£10,000 £-0- -£20,000

The IRR for the marginal project (B – A) is 41.42 percent. This may appear to be quite acceptable, because 41.2% is greater than the 5 percent discount rate. However, it is critical to see that the marginal project (B – A) is a lending investment, because the first non-zero cash flow is positive as is the case when one borrows funds. The IRR for a lending investment is the interest rate on the loan, so that the marginal project (B – A) involves a loan in time period 1 to be paid back in time period 3 with an interest rate of 41.42 percent. This marginal “project” should not be accepted because the interest rate that this loan involves is greater than the market’s cost of money. Hence, the analysis lead to the decision to accept Project A.

## **8.2.2. Mutually Exclusive Projects II**

Imagine that mutually exclusive projects X and Y are both 3-year projects with cash flow patterns in time periods 0, 1, 2 and 3 as shown below.

Period 0 Period 1 Period 2 Period 3

Project X -$50,000 $40,000 $25,000 $5,000

Project Y -$50,000 $20,000 $25,000 $30,000

Assume that the cost of capital is 8% per period.

Choose between Project X and Project Y *based on the Internal Rate of Return*.

ANSWER

For X NPV at 8% is $12,439.67 and IRR is 25.9868%

For Y NPV at 8% is $13,766.96 and IRR is 21.6478%

Ranking by IRR gives a different ranking than by NPV.

Thus, when ranking by IRR it is necessary to engage in a further analysis that concerns the marginal project (Y – X), as X is higher ranked by IRR than is Y.

Period 0 Period 1 Period 2 Period 3

Project X -$50,000 $40,000 $25,000 $5,000

Project Y -$50,000 $20,000 $25,000 $30,000

(Y – X) 0 -20,000 0 +25,000

The IRR for (Y – X) is 11.80%, higher than the 8% cost of capital, and thus this marginal project is acceptable.

As X is acceptable, and (Y – X) is acceptable, it follows that Y is more acceptable than X by IRR, with a ranking that is consistent with the NPV ranking.

While it would be quite easy to analyze all projects using NPV, and avoid the problems that exist with IRR, the difficulty lies with the popularity of IRR compared to NPV in the business community. The popular use of IRR makes addressing the conceptual difficulties with the use of IRR imperative.

## **8.3.1. Lending Investments I**

The Net Present Value (NPV) profile of a 1-year lending investment with the cash flow patterns in time periods 0 and 1 is shown below. As discussed above, a lending investment requires that the first non-zero cash flow be positive, as it is here with a +£20,000 in period 0. The profile represented by the line labeled “NPV profile” on the graph shows the NPV on the vertical axis for a given cost of capital on the horizontal axis, i.e. the NPV of -£5,000 corresponds to a zero percent cost of capital. The borrowing rate on a lending investment is its IRR, which in this case is 25 percent.

Period 0 Period 1

Lending Investment +£20,000 -£25,000

£ NPV profile

25% %

-£5,000

IRR - the borrowing rate on the lending investment

If the borrowing rate (25 percent) is greater than the cost of capital (which is not given in this example), a lending investment should be rejected, but if the borrowing rate is less than the cost of capital, a lending investment should be accepted. In the latter case, one can borrow at a lower rate than the market’s rate, such as when credit cards offer zero percent interest on cash advances.

Even when these adjustments are made in analyzing mutually exclusive projects with IRR, other popular problems that appear in capital budgeting analysis involve the analysis of two or more projects with unequal lives or unequal scales.

## **8.3.2. Lending Investments II**

An investment with the following cash flow patterns in periods 0 and 1 exists. The cost of capital is 12% per period.

Period 0 Period 1

Lending Investment +$100,000 -$110,000

Is this investment acceptable or not?

ANSWER

The IRR for this investment is 10% and lower than the cost of capital of 12%.

However, this is a lending investment, so that the IRR is the borrowing rate – the rate on a loan.

As the IRR on this loan is less than the cost of capital, this lending investment has positive value – one can borrow for a lower rate than one can invest for.

This result is confirmed by examining the NPV for this investment, equal to $100,000 - $110,000/1.12 = $100,000 - $98,214.29 = $1,785.71.

## **8.4.1. Projects with Unequal Lives I**

An existing machine must be replaced by one of two new models, each costing £20,000. The first model will produce savings of £15,000 per year and has a life of 4 years (conceptually, when a machine produces savings, this amount may be equivalently treated as an increase in cash flows). The second model will produce savings of £22,000 per year and has a life of 2 years. If the cost of money is 8 percent, which machine should be purchased?

First, calculated the NPV for each model based on the cash flows for each model’s respective lives, and then based on the value of NPV for each, calculate annual equivalent annuities for each based on their respective lives.

For the first model,

NPV1 = £29,681.90 = -£20,000 + £15,000 (PVIFA,8%,4)

The annual equivalent annuity of NPV1 is the solution for PMT in the following equation,

£29,681.90 = PMT (PVIFA,8%,4),

and PMT is £8,961.58. Note that the annual equivalent annuity is the annuity derived for the life length and the cost of capital given the value of NPV.

For the second model,

NPV2 = £19,231.82 = -£20,000 + £22,000 (PVIFA,8%,2)

The annual equivalent annuity of NPV2 is the solution for PMT in the following equation,

£19,231.82 = PMT (PVIFA,8%,2),

and PMT is £10,784.62.

In this example, the initial impression would be to choose the first model, because when first calculated its NPV is higher. But such a conclusion ignores the fact that perhaps the NPV for the first model is higher because its life is longer. It the lives were the same, would we arrive at the same results. The equivalent annuities based on each model’s NPV would say no. We would rather choose the second model because it produces higher annual equivalent savings compared to the first model (and the cost of money is the same for both machines).

The fact that the cost of money is the same in both instances also means that the capitalized value of the annual equivalent savings will be higher for the second model regardless of the number of years for which the analysis is performed. The capitalized value of the annual equivalent savings for each model assuming perpetuity (a model is always replaced when its usable life is over) are shown below.

The capitalized value is £112,019.75 for the first model (equal to £8,961.58 / .08) and £134,807.75 for the second model (equal to £10,784.62 / .08), and hence the second model would be chosen based on capitalized values. These capitalized values are the NPVs of each model assuming perpetual reinvestments in these models at the end of each of their respective lives.

The second model can also be shown to have a higher NPV than the first model if its life is extended to 4 years, making both models’ lives equal. Of course, the NPV of the second model over a 4 year life span would equal in part the NPV of the second model over its initial 2 year life span, i.e. £19,231.82 as shown above. But it would now be assumed that at the end of two years, a reinvestment in this model is made, extending the life to 4 years. The present value of the reinvestment is the present value of a £19,231.82 future value 2 years hence, because the net value of the reinvestment in two years is £19,231.82, assuming no inflation. The NPV for the second model over a 4 year life is £35,720.01, as shown below, and higher than the £29,681.90 NPV of the second model over its 4 year life.

NPVsecond model for 4 years = £19,231.82 + £19,231.82 (PVIF,8%,2)

= £19,231.82 + £16,488.19 = £35,720.01

## **8.4.2. Projects with Unequal Lives II**

A firm needs to make an acceptance decision between the two mutually exclusive projects A and B.

Each project requires an initial cash outflow of $50,000.

Project A is expected to generate cash inflows over 3 years in the amount of $22,000 per year.

Project B is expected to generate cash inflows over 6 years in the amount of $13,000 per year.

The cost of capital for both projects is 11% per year.

Advise this firm on which project to accept using the capital budgeting technique in which the net present value is the capitalized value of the annual equivalent annuity, to address the problem of unequal lives.

ANSWER

First calculate the NPV for each project given their specified lifespans.

NPVA = -50,000 + 22,000 (PVIFA, 11%, 3) = 3,761.72

NPVB = -50,000 + 13,000 (PVIFA, 11%, 6) = 4,996.99

Initially, it appears that B has a higher NPV and should be accepted, except that unequal lives have not yet been accounted for.

Hence, calculate the equivalent annuity for each project.

Equivalent AnnuityA is PMTA in the following: 3,761.72 = PMTA (PVIFA, 11%, 3)

Equivalent AnnuityA is PMTA = 1,539.345

And the capitalized value for A is 1,539.345/.11 = 13,994.045

Equivalent AnnuityB is PMTB in the following: 4,996.99 = PMTB (PVIFA, 11%, 6)

Equivalent AnnuityB is PMTB = 1,181.17

And the capitalized value for B is 1,181.17/.11 = 10,737.92

Thus, after adjusting for unequal lives, A has a higher value than B, and should be accepted.

## **8.5.1. Projects with Unequal Scales**

## Besides unequal lives, projects can have unequal scales, in that the amount required for one project is different than for another project. Assume that mutually exclusive projects A and B are both 1-year projects with the cash flow patterns in time periods 0 and 1 as shown below. The scales are different, because project A requires an investment of £20,000 and project B £35,000.

Period 0 Period 1 IRR

Project A -£20,000 £23,000 15 percent

Project B -£35,000 £39,000 11.43 percent

Assume that the appropriate discount rate for both projects is 5%. Using only the internal rate of return criteria, the following procedures would be used to determine which of these two projects, if any, should be accepted.

The IRR for project A is 15 percent and for project B 11.43 percent. Both projects meet the acceptance criteria, but only one can be chosen because they are mutually exclusive. It appears that project A is best, because it has the highest IRR, but the IRR can give an incorrect ranking of acceptable projects when, among others, scale differences exist. To avoid this problem, it is necessary to examine the marginal investment (B – A), with cash flows as follows.

Period 0 Period 1

B - A -£15,000 £16,000

The IRR for project (B – A) is 6.67 percent, which is greater than the appropriate discount rate of 5%. Therefore, the marginal investment in project B is accepted, and A is rejected.

This decision is confirmed by the NPV, because the NPV for A is £1,904.76 and for B £2,142.86.

Overall, as shown above, instances when two or more projects are evaluated present additional problems in the capital budgeting decision not encountered with the analysis of just one project, especially when one uses the IRR criteria. In reality, most of the time more than one project is involved in capital budgeting decisions.

1. Section excerpted from Chapter 6 in.Varela, Oscar, *International Finance in the World*, Naper Publishing (September 2011), distributed via

   <http://InternationalFinance.NaperPublishing.com>, 565 pages. [↑](#footnote-ref-1)