Introduction to Capital Budgeting and Investment Criteria

Definition of capital budgeting- It is the process of allocating the limited resources among the best investment opportunities. In brief, it is *strategic asset allocation.*

There are several approaches in selecting the best investment opportunities, but in this note we will use three important that would meet the following criteria:

1.It’s based on time value of money

2. It’s based on investment risk

3. It creates value for the firm (stockholder wealth maximization)

There are three standard concepts used in capital budgeting:

1. The NPV Rule for selecting investments or projects

2. The IRR Rule for selecting investments or projects

3. Profitability Index

**1. The NPV Rule for Selecting Investments and Projects**

The goal of financial management is to create value for the stockholders. Capital budgeting is a process of allocating limited resources among the best investment opportunities. In this section we will introduce the basic NPV and IRR concepts and their application to capital budgeting. We start off by summarizing each of these rules—the NPV rule in this section and the IRR rule in the following section.

Here’s a summary of the decision criteria for investments implied by the net present value:

**The NPV rule for deciding whether or not a specific project is worthwhile:** Suppose you are considering a project that has cash flows *C*0*, CF*1*, CF*2 *, . . . , CFT* . Suppose that the appropriate discount rate for this project is *R*. Then the NPV of the project is:



OR



For an uneven series of the cash flows, the NPV is:



Note that C0 is the initial cost and is a cash outflow.

**Rule:** A project is worthwhile by the NPV rule if its NPV > 0.

**The NPV rule for deciding between two mutually exclusive projects:** Suppose you are trying to decide between two projects A and B, each of which can achieve the same objective.

For example, your company needs a new widget machine, and the choice is between widget machine A and machine B. You will buy either A or B (or perhaps neither machine, but you will certainly not buy both machines). In finance jargon, these projects are **“mutually exclusive.”**

Suppose project A has cash flows *C*A0*, CF*A1*, CF*A2 , *. . ., CFAT* and that project B has cash flows *C*B0*, CF*B1*, CF*B2 *, . . . , CFBT .*

**Rule:** Project A is preferred to project B if *NPV (*A*)* > *NPV (*B*).*

The logic of both NPV rules presented above is that the *present value* of a project’s cash flows

—is the economic value today of the project. Given a discount rate of *R* percent *for* the project, the PV is what the project ought to sell in the market. The net present value is the *wealth increment* produced by the project, so that NPV> 0 means that a project adds to the wealth of stockholders. 

where is the market value of future cash flows and C0 is the initial cash outflow required to implement the project.

**An Example**

Assume that you’re trying to decide whether to undertake one of two projects.

Project A involves buying expensive machinery that produces a better product at a lower cost. The machine for project A costs $2,000 and, if purchased, the project will produce cash flows of $1,000 per year for the next five years. Project B’s machine is cheaper, costing $1,600, but it produces smaller annual cash flows of $840 per year for the next five years. Assume that the discount rate is 12%. The NPV’s of both projects are given in the table below.

|  |  |  |
| --- | --- | --- |
| Estimation of NPV and IRR | | |
| Discount rate | | 12% |
| Year | Project A | Project B |
| 0 | -$2,000 | -$1,600 |
| 1 | $1,000 | $840 |
| 2 | $1,000 | $840 |
| 3 | $1,000 | $840 |
| 4 | $1,000 | $840 |
| 5 | $1,000 | $840 |
| NPV | $1,604.78 | $1,428.01 |
| NPV(A) 1604.78> NPV(B) 1428.01 | | |
| IRR | 41% | 44% |

**2. The IRR Rule for Selecting Investments**

An alternative to using the NPV criterion for capital budgeting is to use the internal rate of return (IRR). The IRR is defined as the discount rate for which the NPV equals zero.

. This equation can be written as:

 or 

If the cash flows are uneven series, then, we need to solve for IRR based on the equation shown below:



It is the compound rate of return that you get from a series of cash flows. Here are the two decision rules for using the IRR in capital budgeting.

**The IRR rule for deciding whether or not a specific investment is worthwhile:** Suppose we are considering a

**Rule:** If the appropriate discount rate for a project is *R*, you should accept the project if its

IRR *>R* and reject it if its IRR *< R.*

**TWO PROJECTS**

Both projects are worthwhile since each has a positive NPV. If we must choose between the projects, then project A is preferred to project B because it has the higher NPV.

The logic behind the IRR rule is that the IRR is the compound return you get from the project.

Since *R* is the project’s required rate of return, it follows that if the IRR *>R*, you get more than you require.

**The IRR rule for deciding between two competing projects:** Suppose you are trying to decide between two mutually exclusive projects A and B (meaning: both projects are ways of achieving the same objective, and you will choose at most one of the projects). Suppose project A has cash flows *C*A0*, CF*A1*, CF*A2 , *. . ., CFAT* and that project B has cash flows *C*B0*, CF*B1*, CF*B2 *, . . . , CFBT .*

**Rule:** Project A is preferred to project B if IRR (A) *>* IRR (B).

Again, the logic is clear: Since the IRR gives a project’s compound rate of return, if we choose between two projects using the IRR rule, we prefer the higher compound rate of return. Applying the IRR rule to our projects A and B, IRRA = 41% and IRRB = 44%

**Decision Rule for Two Projects**

Both project A and project B are worthwhile, since each has an IRR *>* 12%, which is our relevant discount rate. If we have to choose between the two projects by using the IRR rule, project B is preferred to project A, because it has a higher IRR.

**3. NPV or IRR, Which to Use?**

|  |  |  |
| --- | --- | --- |
| Summary of the NPV and IRR rules: | | |
| Criterion | “Accept or Reject”:  Choosing Whether or Not to  Undertake a Single Project | “Project Ranking”:  Comparing Two Mutually  Exclusive Projects |
| NPV criterion | The project should be undertaken if its NPV > 0. | Project A is preferred to project B if NPV (A) > NPV(B). |
| IRR criterion | The project should be undertaken if  its IRR > R, where R is the appropriate  discount rate | Project A is preferred to project B if IRR (A) > IRR(B). |

**DECISION CRITERIA**

**1.NPV>0, IRR>R,**

**2.NPV<0, IRR<R,**

**3.NPV=0, IRR=R,**

Both the NPV rules and the IRR rules look logical. In many cases the investment decision—to undertake a project or not, or which of two competing projects to choose—will be the same whether using NPV or IRR. There are some cases, however (such as that of projects A and B illustrated above), where NPV and IRR give different answers. In the present value analysis, project A won out because its NPV is greater than project B’s. In the IRR analysis of the same projects, project B was chosen because it had the higher IRR. In such cases, the NPV should be used to decide between projects. The logic is that if financial managers are interested in maximizing stockholders’ wealth, they should use NPV, which measures the incremental wealth from undertaking a project.

**4. The “Accept-Reject” Criterion: When Do IRR and NPV**

**Give the Same Answer?**

Consider the following project. The initial cash flow of -$2,000 represents the cost of the project today, and the remaining cash flows for years 1–6 are projected future cash flows. The discount rate is 15%.

|  |  |  |
| --- | --- | --- |
| 1. You are considering a project whose cash flows are given below:  (a) Calculate the present values of the future cash flows of the project.  (b) Calculate the project’s net present value.  (c) Calculate the internal rate of return.  (d) Should you undertake the project? | | |
| Discount rate | | 15% |
|  | Year | Cash flow |
|  | 0 | -2000 |
|  | 1 | 200 |
|  | 2 | 400 |
|  | 3 | 600 |
|  | 4 | 800 |
|  | 5 | 1000 |
|  | 6 | 1200 |
| PV of future cash flows | | $1,172.13 |
| NPV |  | $344.25 |
| IRR |  | 19.71% |

The NPV of the project is $172.13, meaning that the present value of the project’s future cash flows ($1,172.13) is greater than the project’s cost of $1,000.00. Thus, the project is worthwhile.

If we graph the project’s NPV we can see that the IRR—the point where the NPV curve crosses the *x*-axis—is very close to 20%. As you can see the actual IRR is 19.71%.

**Constructing an NPV Profile**. First calculate NPV at different discount rate shown in table below. Then put the discount rate on horizontal x- axis and NPV on the vertical y-axis similar to graph below.

|  |  |
| --- | --- |
| Discount Rate | NPV |
| 0% | $2,200.00 |
| 3% | $1,698.68 |
| 6% | $1,275.34 |
| 9% | $915.66 |
| 12% | $608.32 |
| 15% | $344.25 |
| 18% | $116.20 |
| 21% | ($81.71) |
| 24% | ($254.28) |
| 27% | ($405.41) |
| 30% | ($538.33) |



**Accept or reject? Should We Undertake the Project?**

The above project is worthwhile:

• Its NPV > 0, so that by the NPV criterion the project should be accepted.

• Its IRR of 19.71% is greater than the project discount rate of 15%, so that by the IRR criterion the project should be accepted.

**5. Do NPV and IRR Produce the Same Project Rankings?**

In the previous section we saw that, for conventional projects, NPV and IRR give the same “Yes–No” answer about whether to invest in a project. In this section we see that NPV and IRR do not necessarily *rank* projects the same, even if the projects are both conventional.

Suppose we have two projects and can choose to invest in only one. The projects are *mutually exclusive:* They are both ways to achieve the same end, and thus we would choose only one.

In this section we discuss the use of NPV and IRR to rank the projects. To sum up our results before we start:

• Ranking projects by NPV and IRR can lead to possibly contradictory results. Using the NPV criterion may lead us to prefer one project whereas using the IRR criterion may lead us to prefer the other project.

• Where a conflict exists between NPV and IRR, the project with the larger NPV is preferred.

That is, the NPV criterion is the correct criterion to use for capital budgeting. This is not to impugn the IRR criterion, which is often very useful. However, NPV is preferred over IRR because it indicates the *increase in wealth* that the project produces.

**An Example**

Below we show the cash flows for project A and project B. Both projects have the same initial cost of $500 but have different cash flow patterns. The relevant discount rate is 15%.

|  |  |  |
| --- | --- | --- |
| **Year** | **Project A** | **Project B** |
| 0 | -$30,000.00 | -$30,000.00 |
| 1 | $16,000.00 | $6,000.00 |
| 2 | $13,000.00 | $8,000.00 |
| 3 | $8,000.00 | $10,000.00 |
| 4 | $5,000.00 | $12,000.00 |
|  | $3,000.00 | $15,000.00 |
| NPV | $3,353.34 | $2,160.39 |
| IRR | 21.22% | 17.57% |

***Comparing the Projects Using IRR:*** If we use the IRR rule to choose between the projects, then A is preferred to B, since the IRR of project A is higher than that of project B.

***Comparing the Projects Using NPV:*** Here the choice is more complicated. When the discount rate is 15% (as illustrated above), the NPV of project A is higher than that of project B. In this case the IRR and the NPV agree: Both indicate that project A should be chosen. Now suppose that the discount rate is 8%; in this case the NPV and IRR rankings conflict:

|  |  |  |
| --- | --- | --- |
| **Year** | **Project A** | **Project B** |
| 0 | -$30,000.00 | -$30,000.00 |
| 1 | $16,000.00 | $6,000.00 |
| 2 | $13,000.00 | $8,000.00 |
| 3 | $8,000.00 | $10,000.00 |
| 4 | $5,000.00 | $12,000.00 |
| 5 | $3,000.00 | $15,000.00 |
| NPV | $8,027.78 | $9,381.69 |
| IRR | 21.22% | 17.57% |

In this case we have to resolve the conflict between the ranking on the basis of NPV (project A is preferred) and the ranking on the basis of IRR (project B is preferred). As we stated in the introduction to this section, the solution to this conflict is that you should choose on the basis of NPV. We explore the reasons for this later on, but first we discuss a technical question.

**Why Do NPV and IRR Give Different Rankings?**

Below we build a table and graph that show the NPV for each project as a function of the discount rate:

|  |  |  |
| --- | --- | --- |
| NPV Profiles for Mutually Exclusive Investments | | |
| R | NPV (A) | NPV (B) |
| 0% | $15,000.00 | $21,000.00 |
| 2% | $13,056.47 | $17,667.03 |
| 4% | $11,255.62 | $14,642.20 |
| 6% | $9,583.49 | $11,890.54 |
| **8%** | **$8,027.78** | **$9,381.69** |
| 10% | $6,577.61 | $7,089.25 |
| 11.347% | $5,655.51 | $5,655.52 |
| 14% | $3,956.45 | $3,064.11 |
| **15%** | **$3,353.34** | **$2,160.39** |
| 16% | $2,769.28 | $1,293.48 |
| 18% | $1,655.04 | ($337.37) |
| 20% | $607.64 | ($1,842.21) |
| 22% | ($378.39) | ($3,233.22) |
| 24% | ($1,307.95) | ($4,521.20) |
| 26% | ($2,185.48) | ($5,715.75) |
| 28% | ($3,014.97) | ($6,825.39) |
| 30% | ($3,800.04) | ($7,857.76) |



From the graph you can see why contradictory rankings occur:

• Project A has a higher IRR (21.22) than project B (17.57%). (Remember that the IRR is the point at which the NPV curve crosses the *x*-axis.) • When the discount rate is low, project B has a higher NPV than project A, but when the discount rate is high, project A has a higher NPV. There is a crossover point (in the next subsection you will see that this point is 11.347%) that marks the disagreement/agreement range.

• Project B’s NPV is more sensitive to changes in the discount rate than project A’s NPV. The reason for this is that project B’s cash flows are more spread out over time than those of project A; another way of saying this is that project B has substantially more of its cash flows at later dates than project B.

To summarize:

|  |  |  |  |
| --- | --- | --- | --- |
| Criterion: | Discount Rate < 11.347% | Discount Rate = 11.347% | Discount Rate >11.347% |
| NPV criterion | Project B preferred: | Indifferent between projects | A Project A preferred: |
|  | NPV(B) *>* NPV(A) | NPV(A) = NPV(B) | NPV(A) *>* NPV(B) |
| IRR criterion | Project A is always preferred to project B, since IRR (A) *>* IRR (B) | | |

**Calculating the Crossover Point**

The crossover point—which we claimed earlier was11.35%—is the discount rate at which the NPVs of the two projects are equal. A bit of formula manipulation will show you that *the crossover point is the IRR of the differential cash flows*. To see what this means, consider the Column that contains the differential cash flows—the difference between the cash flows of project A and project B. In that column we calculate the **IRR**  to compute the crossover point.

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Project A** | **Project B** | **Differential**  **Cash Flows** |
| 0 | -$30,000.00 | -$30,000.00 | $0.00 |
| 1 | $16,000.00 | $6,000.00 | $10,000.00 |
| 2 | $13,000.00 | $8,000.00 | $5,000.00 |
| 3 | $8,000.00 | $10,000.00 | -$2,000.00 |
| 4 | $5,000.00 | $12,000.00 | -$7,000.00 |
|  | $3,000.00 | $15,000.00 | -$12,000.00 |
| NPV | $3,353.34 | $2,160.39 | ($1,353.92) |
| IRR | 21.22% | 17.57% | 11.35% |

**What to Use? NPV or IRR?**

Let’s go back to the above example and suppose that the discount rate is 8%:

|  |  |  |
| --- | --- | --- |
| **Year** | **Project A** | **Project B** |
| 0 | -$30,000.00 | -$30,000.00 |
| 1 | $16,000.00 | $6,000.00 |
| 2 | $13,000.00 | $8,000.00 |
| 3 | $8,000.00 | $10,000.00 |
| 4 | $5,000.00 | $12,000.00 |
| 5 | $3,000.00 | $15,000.00 |
| NPV | $8,027.78 | $9,381.69 |
| IRR | 21.22% | 17.57% |

In this case, we know there is disagreement between the NPV (which would lead us to choose project B) and the IRR (by which we choose project A. Which is correct?

The answer to this question—for the case where the discount rate is 8%—is that we should choose based on the NPV (that is, choose project B). This is just one example of the general principle discussed in 3: *Using the NPV is always preferred,* since the NPV is the additional *wealth* that you get, whereas IRR is the compound rate of return. The economic assumption is that consumers maximize their wealth, not their rate of return.

Project Selection with Limited Resource

The previous discussion has assumed that resources are unlimited. If resource constraints exist, simply picking the highest NPV project will not always lead to the best decision. Sometimes a different combination of projects will result in a higher overall NPV. In this case, a profitability index often helps. The profitability index can be computed as follows:

**Profitability Index**

Or



Note that this text treats PI a little differently than the typical text. First, NPV is in the numerator, rather than PV of future cash flows. Also, the resource constraint need not be financial. It could be human resources constraint.

The result of the PI calculation can be used to rank projects. In some situations, however, PI does not give an accurate answer. For example, sometimes there are leftover resources if PI is strictly applied. If projects could be found that would use only those resources, the overall NPV would improve. Also, in some cases there is more than one resource constraint. In those cases, the only way to assess the best scenario is to sort through all the possibilities. With computer-based linear programming tools, this is not as difficult as it sounds.