PreMBA *finance*

Evaluating Cash Flows: NPV & IRR

How Do Companies Decide Which Projects to Undertake?

This discussion of **net present value** and **internal rate of return** examines how companies use NPV and IRR as decision tools to evaluate whether investments or projects are worth pursuing.

The **perpetuities** topic introduced the dividend discount model as a way to value a company's stock. Aside from buying stock back from the public, **cash dividends** are the common way that a company returns cash payments to its equity investors.

Where does the company get the cash to pay the dividends? The company generates cash from the projects that it undertakes with the cash that it acquires from investors (both debt and equity investors) and any excess cash generated by its projects.

Investors base their **required rate of return** on the riskiness of the company's projects. The more **risk** investors perceive in the cash flows from the projects, the higher the rate of return investors will require from the company. The combined return required by debt and equity capital is the weighted average **cost of capital**, or simply the cost of capital.

Investment versus financing
A key concept of business finance requires separating the investment decision from the financing decision. The liabilities and net worth comprise the source of funds—where the company gets its money. The assets represent how those funds are invested—the investment decision. The key point is that it does not matter what the source of funds is when evaluating an investment.

For example, suppose an airline wanted to acquire an airplane for a new route. The investment project is the new route. The airplane and crew, ground personnel, fuel, ticketing, airport fees, and so on represent the costs, or cash outflows, of this project. The revenues from ticket sales are the revenues or cash inflows of the project. These aspects of the project will remain the same regardless of how the airline finances the project. The cost of the airplane is considered a cash outflow. The firm could pay for the airplane with cash raised by selling other assets, by using available cash, by borrowing from a bank, issuing bonds, or issuing more stock. Even a lease represents a form of financing. It does not matter what the source of funds is when evaluating an investment.

So how does the firm take financing costs into account? Firms use the cost of capital.

Cost of capital
The cost of capital reflects the minimum amount that a firm must earn on its assets in order for those assets to add value to the firm. Expressed as a percent, the cost of capital is the rate at which assets must provide cash inflows

Does using returnable containers save a company money? Read about how to evaluate this option using net present value.

Article

Can You Justify Returnables?

to justify their cost. Therefore, if the rate of return of the net cash flows from a project, including the initial investment and all future net cash flows, exceeds the cost of capital, the project will add to the value of the firm. This was the case in Challenge B. There you found that the assets generated a return of 21.31 percent, while the cost of capital was assumed to be 15 percent.

Understanding the derivation of the cost of capital requires a review of how equity markets work, which goes beyond the scope of this course. For the purpose of this topic, assume that the company's financial manager has derived a value for the cost of capital to use in evaluating projects.

Value additivity
Value additivity is the concept that the present value of a company equals the sum of the present value of independent projects. For projects to be evaluated independently, the cash flows from new projects must include the effects that new projects have on existing projects. This simple concept compels financial managers to go back and reevaluate existing projects and helps managers focus on all of the relevant cash flows attributable to the new project.

Relevant cash flows
Constructing the relevant cash flows for project evaluation is important and sometimes difficult. Some **financial instruments**, such as bonds and mortgages, present a fairly well-defined set of cash flows. Other financial instruments, such as options, futures, and derivatives, can have complex cash flows dependent on several factors. Most business projects require as much art as science in projecting the cash inflows and cash outflows of a project, including the effects of proposals on existing undertakings.

More advanced courses will deal with computing the cost of capital projects and relevant cash flows of the firm's projects. The remainder of this section will consider two methods analysts use to evaluate the cash flows of different projects, regardless of when those cash flows occur. These two methods are the net present value (NPV) and the internal rate of return (IRR).

Projects with a Positive NPV Add Value to the Firm

How does an entrepreneur use net present value?
Low bandwith

High bandwith

The net present value, or NPV, is one of the most common methods used to evaluate investments. At its simplest, NPV is the present value computed by using the firm's cost of capital as the discount rate of cash inflows, minus the present value of cash outflows, including the initial investment.

$$\text{NPV} = \begin{pmatrix}\text{PV of}\\ \text{Cash}\\ \text{Inflows}\end{pmatrix} - \begin{pmatrix}\text{PV of}\\ \text{Cash}\\ \text{Outflows}\end{pmatrix}$$

Cash inflows and outflows can occur at any time during the project. The NPV of the project is the sum of the present values of the net cash flows for each time period t, where t takes on the values 0 (the beginning of the project) through N (the end of the project).

$$\text{NPV} = \begin{pmatrix}\text{PV of Net}\\\text{Cash Flows}\end{pmatrix}$$

Analytical Methods: Summation

This can be expressed as

$$\text{NPV} = \sum_{t=0}^{N} \frac{C_t}{(1+r)^t}$$

Sometimes, for convenience, this can be written with the initial cash flow listed separately as

$$\text{NPV} = \sum_{t=1}^{N} \frac{C_t}{(1+r)^t} + C_0$$

C_0 is negative if there is an initial cash outflow.

Exponents

If the present value of the cash flows, discounted at the cost of capital, exceeds the cost of the investment, then the investment will add to the value of the company. The positive NPVs calculated in Challenges B and C, where the discount rates equaled the costs of capital, indicated that those projects would add value to the firm.

Example: Single future cash flow
Consider two simple investments, each with only one future net cash flow.

Assume that each project costs $900. The net present value of each project using different costs of capital are:

Net Present Value of Projects A and B			
Cost of Capital	10%	15%	20%
PV of project A: $2,000 in 5 years Cost: $900	$342	$94	-$96
PV of project B: $3,000 in 8 years Cost: $900	$500	$81	-$202

The net present value indicates that project B is more valuable at a cost of capital of 10 percent, that project A is slightly more valuable at 15 percent, and that neither project would add to the value of the company at a cost of capital of 20 percent.

Which project would you choose?
If the projects are independent, you would choose both if the cost of capital is 15 percent or less. Neither project would be acceptable at a cost of capital of 20 percent, since this would lower the present value of the whole firm. If these are mutually exclusive projects, take the one that adds more to the value of the firm. In this case, that answer depends on the actual cost of capital.

What happens if the projects have different levels of risk?

Bond markets require higher rates of return for bonds from companies in poor financial condition (the so-called *junk bond* market) than the markets do for bonds issued by companies in excellent financial condition (*investment-grade* bonds). One way to account for different levels of risk between competing projects is to increase the cost of capital by some amount to reflect the higher risk. If project B is substantially more risky than project A, such that the NPV of project A is computed at 15 percent whereas the NPV of project B is computed at 20 percent, then the investment decision takes on a new dimension. In this case, only project A would be acceptable.

As with the cost of capital itself, the process for adjusting projects for risk goes beyond the scope of this topic.

Later, in the spreadsheet examples, the NPV of multiple net cash flows is calculated. As the Challenge problems demonstrate, the analysis of net present value is the same whether you have one future cash flow or many.

The NPV calculation is one method analysts use to decide whether a potential project, or investment, can add value to the firm. As you may have seen in Challenge A and Challenge B, the NPV is often calculated assuming a required rate of return on the investment, a rate given in the assumptions of the factual situation. The NPV calculation provides a dollar measure of how much a project is expected to add to a firm's value. Analysts may also want to know what the rate of return on a project is in order to compare it to the cost of capital. This rate is called the internal rate of return, or IRR.

Projects with an IRR Greater than the Cost of Capital Add Value to the Firm

The IRR is the discount rate that makes the present value of the cash inflows equal to the present value of the cash outflows. This is the same as saying that the IRR is the discount rate that makes the net present value equal to zero.

What is the IRR for the two projects above, each of which has an initial investment of $900? Project A provides a net cash inflow of $2,000 at the end of five years. Project B provides a net cash inflow of $3,000 at the end of eight years.

Unlike projects with multiple future net cash flows, the IRR for a single future net cash flow, and a single initial investment, can be computed with a relatively simple formula.

In the "Time Value of Money" section, you learned how to calculate the present value (PV) of a future net cash flow (FV) received *N* periods from now, discounted at a **periodic interest rate** of *r*.

$$PV = \frac{FV}{(1+r)^N}$$

Solving for *r*, the rate of return, produces

$$(1+r)^N = \frac{FV}{PV}$$

$$1+r = \left(\frac{FV}{PV}\right)^{\frac{1}{N}}$$

$$r = \left(\frac{FV}{PV}\right)^{\frac{1}{N}} - 1$$

Let IRR_x be the internal rate of return for project x.

For project A,

FV = \$2,000

$N = 5$

PV = \$900

Therefore, the IRR is

$$IRR = \left(\frac{FV}{PV}\right)^{\frac{1}{N}} - 1$$

$$\begin{aligned} IRR_A &= \left(\frac{FV}{PV}\right)^{\frac{1}{N}} - 1 \\ &= \left(\frac{\$2,000}{\$900}\right)^{\frac{1}{5}} - 1 \\ &= 0.1732 \\ &= 17.32\% \end{aligned}$$

For project B,

FV = \$3,000

$N = 8$

PV = \$900

Therefore, the IRR is

$$\begin{aligned} IRR_B &= \left(\frac{FV}{PV}\right)^{\frac{1}{N}} - 1 \\ &= \left(\frac{\$3,000}{\$900}\right)^{\frac{1}{8}} - 1 \\ &= 0.1624 \\ &= 16.24\% \end{aligned}$$

You will find businesses using both the NPV and IRR calculations to aid in making investment decisions. IRR is a potentially flawed decision tool because it can be easily misapplied. IRR problems include:

- Lending versus borrowing. For some projects that have cash inflows followed by cash outflows, the NPV *rises* as the discount rate is increased. In this case, projects in which the IRR is *less* than the cost of capital are acceptable.
- Multiple rates of return. If there is more than one change in the sign of the cash flows, the project may have several IRRs, or no IRR.
- Mutually exclusive projects. The IRR rule may not accurately rank mutually exclusive projects that vary in time or scale.
- Short-term interest rates may be different from long-term rates. In a single project, the cost of capital for one-year cash flows can differ from the cost of capital for two-year cash flows, and so on. This does not allow you to compare the project's IRR with the cost of capital. In these cases, there is no straightforward method for calculating the project's IRR.

The following animation demonstrates how IRR can lead to faulty decision-making.

IRR Animation
View **animation**

Evaluating multiple net cash flows
The basic approach used for projects with a single net cash inflow after the initial investment also applies to projects with multiple future net cash inflows. Annuity formulas aid computations when all cash flows are equal in amount, but when cash inflows vary over time, computations are more tedious.

Example
Analyze a project with quarterly net cash flows using a discount rate of 3 percent per quarter. The following table shows the cash flows by quarter.

For this project, the investment is the initial cash flow. By convention, outflows appear as negative numbers; net cash inflows are positive.

Cash Flows by Quarter	
Quarter	Net Cash Flow
0	-$900
1	$250
2	$300
3	$400
4	$20

STEP 1
Obtain the cost of capital, 3 percent per quarter, and generate discount factors. From the present value of a single payment, the *discount factor* for period *t* at a periodic interest rate of *r* is

$$\text{Discount Factor} = \frac{1}{(1+r)^t}$$

Cash Flows by Quarter		
Quarter	Net Cash Flow	Discount Factor $\frac{1}{(1+.03)^{\text{Quarter}}}$
0	-$900	1.000000
1	$250	0.970874
2	$300	0.942596
3	$400	0.915142
4	$20	0.888487

STEP 2

Compute present values of each net cash flow. Multiply the net cash flow for each period by its discount factor to obtain its present value.

Cash Flows by Quarter			
Quarter	Net Cash Flow	Discount Factor $\frac{1}{(1+.03)^{\text{Quarter}}}$	Present Value
0	-$900	1.000000	-$900.00
1	$250	0.970874	$247.72
2	$300	0.942596	$282.78
3	$400	0.915142	$366.06
4	$20	0.888487	$17.77

STEP 3

Sum the present values of each cash flow to calculate the NPV.

Net Present Value	
Quarter	Present Value
0	-$900.00
1	$247.72
2	$282.78
3	$366.06
4	$17.77
NPV	$9.32

The NPV for this project is $9.32.

Find the IRR, the discount rate, that makes the NPV zero. See the spreadsheet example below.

Spreadsheet Examples

Net present value
Most modern spreadsheets have financial **spreadsheet functions** that can compute NPV and IRR.

You can use Excel to solve NPV

NPV Excel Tutorial

Although the exact form may vary, the NPV spreadsheet function typically takes the form

NPV (discount rate, net cash flows for t = 1 to N)

The discount rate is a value or cell address for the periodic rate. Since the cash flows occur at quarterly intervals, the discount rate must be entered as a decimal quarterly rate.

Net cash flows for t = 1 to N means that the cell range for only the future net cash flows must be entered. As a result, the NPV is not NPV as defined here, but the PV of future cash flows. The initial investment must be subtracted from the result of the NPV function to get the actual net present value. (See the cell range for IRR by comparison.)

Net Present Value = NPV function + initial investment (as negative number).

Using the quarterly cash flows in the example above, enter in a new spreadsheet, in cells A1 through A5, the values: -900, 250, 300, 400, and 20.

In cell B6, enter the quarterly discount rate 0.03.

In cell A6, enter the formula =NPV(B6,A2:A5)+A1.

The result should be $9.32.

Internal rate of return
Unlike the spreadsheet version of NPV, the IRR function actually uses the values for time periods 0 through N:

You can use Excel to solve IRR

IRR Excel Tutorial

IRR (net cash flows for t = 0 to N, {optional guess discount rate}).

The net cash flows for t = 0 to N are the range of cells with all net cash flows, including the initial investment as a negative number.

The optional "guess discount rate" allows the user to enter a value or cell that contains a "guess" as to the value of the IRR in its periodic form, such as .012 annually, .03 for quarterly, and .01 for monthly.

Using the same information in the NPV example above, enter in cell A7 the formula =IRR(A1:A5).

The answer should be 3.4897 percent. (You may need to increase the number of decimals displayed, or the result may appear to be 3 percent). This is the quarterly IRR.

To compute the **effective annual rate** (EAR) needed to evaluate the annual cost of capital, use the formula presented in Future Value in the "Time Value of Money" section:

The effective annual rate is

$$\begin{aligned} \text{EAR} &= (1+r)^m - 1 \\ &= (1+0.034897)^4 - 1 \\ &= 0.1471 \\ &= 14.71\% \end{aligned}$$

Here *m* is the **compounding frequency**. Notice that this is not the same as multiplying the quarterly rate by 4, which is 13.96 percent. The annual nominal rate is 13.96 percent.

Hint: Do not compare the annualized nominal rate to the cost of capital stated at an annual rate. Instead, compare the EAR with the annual cost of capital.

Summary

- The cost of capital is the discount rate companies use to evaluate projects. It will vary from project to project depending on the assessed risk of each project.
- The *investment decision* is separate from the *financing decision.*
- Value additivity is the theory that the present value of a company is equal to the sum of the present values of all of the company's independent projects.
- Relevant cash flows include the initial investment, cash inflows, and cash outflows for a new project, plus the changes in cash flow on existing projects.
- Net present value is the net dollar benefit of a new project discounted at the cost of capital. NPV must be positive to add value to the firm.
- The internal rate of return is the discount rate that makes the NPV equal to zero. IRR must be greater than the cost of capital for a new project to add value to the firm.

How do spreadsheets find the IRR?

How many decimal places should you use?

1. Calculate the internal rate of return for the following set of cash flows by first using trial and error. The initial cash outflow is $8,145, followed by seven years of semiannual cash inflows of $890. The associated discount rate is 5.6 percent.
Hint: There is a concise way to solve by trial and error.

Solution 1

2. Your company will invest $5 million to receive payments of $2 million for the next 10 years. Calculate the NPV if the required rate of return is 14 percent per year.

Solution 2

Alternate Solution 2

3. After graduation, you landed a job at a large, multinational media corporation. Your firm has been negotiating a license agreement to use a certain documentary film for a term of 2.5 years. You expect that the film will return cash flows of $12.5 million at the end of each six-month period. The company licensing the rights to use the film is asking $50 million. Your company's required rate of return is 17.5 percent. Should you purchase the license to show the film?

Solution 3

Alternate Solution 3

4. Consider the following information pertaining to a project that your company is currently evaluating. The project calls for your factory to add a second canning machine that will result in end-of-year cash flows of $3,200, $3,700, $4,100, $4,500, and $4,900 over the next five years. The canning machine will cost $15,000, and your company uses a 13 percent discount rate when evaluating projects. What is the net present value of these cash flows?

Solution 4

Alternate Solution 4

5. Take a set of four annual cash flows starting at the end of year 0: -$1,000, +$400, +$600, and +$800. Compute the IRR. Then compute the FV of each cash flow using the IRR as the compounding interest rate. Sum these FVs. What is the net future value? Using the sum of the future values for the cash inflows in years 1, 2, and 3, what is the IRR of this single future value against the initial investment of $1,000? (Use the formula to compute the IRR of a single future cash flow.)

Solution 5

6. Take the same cash flows in the question above. The IRR was fairly high at 31.69 percent. What if the cash flows from the project cannot be reinvested at the IRR? (No other project at that level exists.) Compute the future value of the cash flows at the end of year 3 using a lower interest rate, such as 12 percent. Add the future cash inflows to derive a single sum cash equivalent inflow as of the end of year 3. Now compute the IRR using the formula for a single future cash inflow at the end of year 3. What happens to the IRR?

Solution 6

7. A wine lover has decided to start a winery. The initial investment will be $5 million. The winery will require additional investments of $1 million per year at the end of the next five years while the vines mature. Beginning at the end of year 6, the winery is expected to produce net cash inflows of $2 million at the end of each year, growing

at 20 percent per year. How long will it take the project to reach a positive net present value, assuming an annually compounded discount rate of 15 percent?

Solution 7

8. Using the information about the winery in the previous question, when would the IRR exceed the discount rate of 15 percent if there is an additional $4 million expenditure in year 10, with no change in revenues?

Solution 8

Previous | **Next**