



NPV & IRR
Tutorial
February 2017

1.0 General

Please note the following guidance and instruction is to be used as an accompaniment to the 'NPV & IRR' Excel file.

Please feel free to get in touch at contact@lentransolutions.com if you would like additional guidance or to discuss the methodologies represented here and in the Excel file.

2.0 Tutorial

2.1 Aim and audience

The aim of this tutorial is to illustrate modelling approaches in calculating the Net Present Value (NPV) and Internal Rate of Return (IRR). The intended audience are those preparing valuation models who seek to evaluate the returns and profitability of an investment. This tutorial also assumes that the reader already has basic knowledge with the mathematical concept of both the NPV and IRR.

2.2 Introduction and tutorial conventions

NPV and IRR are two of the most commonly used return metrics found in valuation modelling and analysis. In fact, the key outcome (and sometimes the only outputs that matter) are the NPV and IRR in a transaction.

However, they are quite often misused or miscalculated. Therefore, this tutorial will not only illustrate how to set-up the NPV and IRR calculations correctly but also discuss the common pitfalls in calculating them.

Sheet references are displayed as '**Sheet**' while section headings and line references are displayed as '*Item*'.

2.3 Discount rate

A discount rate of 12% has been assumed in this tutorial (**Inputs**) – row 22. The annualised discount rate is then converted to a quarterly discount rate (**Calcs**) – G20.

Due to the effects of compounding, converting an annualised rate to a periodic (in this case quarterly) should be:

$$(1 + i)^{1/n} - 1$$

- i = annualised rate
- n = number of periods

| | A | B | C | D | E | F | G | H | I | J |
|----|---|---|----------------------|----------|--------|---------------|---------------|-----------|-----------|-----------|
| 1 | | | Calculations | | | | | | | |
| 2 | | | Tutorial: NPV & IRR | | | | | | | |
| 3 | | | Period end | Date | | | 31-Dec-17 | 31-Mar-18 | 30-Jun-18 | 30-Sep-18 |
| 16 | | | Evaluation cashflows | AUD '000 | | | (0) | (560) | (834) | 186 |
| 18 | | | | | | | | | | |
| 19 | | | NPV | | % p.a | % p.q (no. 1) | % p.q (no. 2) | | | |
| 20 | | | Discount rate | Various | 12.00% | 3.00% | 2.87% | 2.83% | 2.87% | 2.90% |

2.4 NPV (first principles)

The NPV can be calculated in two ways; using an in-built Excel function or from first principles. We will first calculate NPV from first principles which in essence is the sum of future cashflows (and the initial investment nominal as of today):

$$NPV = -Initial\ Investment + \sum_{t=1}^T \frac{Net\ Cash\ Flow_t}{(1+i)^t}$$

Therefore, a logical way in calculating the NPV from first principles is to (**Calcs**):

1. Calculate the periodic discount rate (i) – row 20
2. Convert the periodic discount rate into an index – row 23
3. Calculate the discounted cashflows by multiplying the periodic cashflows by the discount index – row 24
4. Summing the discounted cashflows to produce the NPV – E24

Now that we've got an intuitively sound approach to calculating the NPV, we will move on to calculating the NPV using an in-built Excel function.

| | A | B | C | D | E | F | G | H | I | J |
|----|---|---|----------------------|----------|--------|---------------|---------------|-----------|-----------|-----------|
| 1 | | | Calculations | | | | | | | |
| 2 | | | Tutorial: NPV & IRR | | | | | | | |
| 3 | | | Period end | Date | | | 31-Dec-17 | 31-Mar-18 | 30-Jun-18 | 30-Sep-18 |
| 18 | | | | | | | | | | |
| 19 | | | NPV | | % p.a | % p.q (no. 1) | % p.q (no. 2) | | | |
| 20 | | | Discount rate | Various | 12.00% | 3.00% | 2.87% | 2.83% | 2.87% | 2.90% |
| 21 | | | | | | | | | | |
| 22 | | | 1st principles | | | | | | | |
| 23 | | | Discount index | Index | NPV | | 1.00 | 1.03 | 1.06 | 1.09 |
| 24 | | | Discounted cashflows | AUD '000 | 313.84 | | | (545) | (788) | 170 |

2.5 NPV (in-built Excel function)

Given that the NPV function is often misunderstood and consequently misused, this tutorial will show you the various methods in calculating the NPV in an incremental way, starting from the very inaccurate (read: wrong) to finally the most accurate way (**Calcs**) – rows 27:32

2.5.1 NPV no. 1

The very first method involves using the in-built NPV function to calculate the NPV. The syntax of the NPV formula should be relatively self-explanatory with two inputs required:

- Discount rate
- Values, which in most cases; cashflows that are to be discounted

This method of calculating NPV is outright incorrect as the NPV formula assumes that cashflows occur are of the same periodicity as the discount rate. Therefore, given that cashflows occur every quarter in this tutorial, discount rates should instead be converted to a quarterly rate.

2.5.2 NPV no. 2

The next NPV calculation attempts to address the NPV function periodicity issue by calculating the NPV based off a quarterly rate by simply dividing the annualised discount rate by its periodicity (4 in this case). However, this is also an inaccurate approach given how the discount rate has been converted with no regard to compounding.

2.5.3 NPV no. 3

In addressing the periodicity conversion issue of the discount rate, the formula in section 2.3 is the correct method to convert an annualised discount rate to a quarterly one. As such, this NPV calculation addresses the issue by using the discount rate in G20.

2.5.4 NPV no. 4 & 5

In this tutorial, evaluation period is 31-Dec-17 rather than 31-Mar-18, therefore, the NPV calculation should start from G17 rather than H17. NPV no. 4 addresses this issue, however, relative to the NPV from first principles calculation, you will notice that it throws the NPV off further.

The reason is because the NPV Excel function unlike the NPV formula, discounts the very first cashflow (i.e. treats it as CF_1 rather than CF_0). Therefore, if the NPV is calculated from column G, the cashflow at period zero should be added separately as done in NPV no. 5:

$$- CF_0 + NPV(i, CF_1 + CF_2 + \dots)$$

2.5.5 XNPV

As useful as the NPV function is, it suffers from one major limitation in that it only works if cashflows are equally spaced with the same periodicity. This is a big issue especially with valuation models where the timing of a transaction may be unequally spaced (i.e. monthly construction and quarterly operations) or cashflows may occur intermittently.

Hence, the more robust alternative is the XNPV function:

XNPV(rate, values, dates)

As per the formula above, it allows the user to input not only the values but the dates that correspond with the values.

It also has two additional features:

- Rates – an annual discount rate with no periodic conversion necessary.
- The first cashflow is not discounted as done in the NPV function (i.e. treats it as CF_0 rather than CF_1).

2.5.6 Discrepancy to 1st principles

As you will notice in E32, the XNPV returned an exact match as the NPV calculated from first principles (also see E35:E40 for all discrepancies). Evidently, apart from first principles, the XNPV is the recommended approach in calculating the NPV formula.

| | A | B | C | D | E |
|----|--------------------------------------|----------|------|----------|---|
| 1 | Calculations | | | | |
| 2 | Tutorial: NPV & IRR | | | | |
| 3 | Period end | | Date | | |
| 25 | <u>NPV & XNPV function</u> | | | | |
| 27 | NPV no. 1 | AUD '000 | | (257.14) | |
| 28 | NPV no. 2 | AUD '000 | | 302.04 | |
| 29 | NPV no. 3 | AUD '000 | | 314.21 | |
| 30 | NPV no. 4 | AUD '000 | | 305.43 | |
| 31 | NPV no. 5 | AUD '000 | | 314.21 | |
| 32 | XNPV | AUD '000 | | 313.84 | |
| 33 | <u>Discrepancy to 1st principles</u> | | | | |
| 35 | NPV no. 1 | AUD '000 | | 570.98 | |
| 36 | NPV no. 2 | AUD '000 | | 11.79 | |
| 37 | NPV no. 3 | AUD '000 | | (0.37) | |
| 38 | NPV no. 4 | AUD '000 | | 8.41 | |
| 39 | NPV no. 5 | AUD '000 | | (0.37) | |
| 40 | XNPV | AUD '000 | | 0.00 | |

2.6 IRR

The internal rate of return (IRR) can be defined as the discount rate at which the net present value of all cashflows from a particular investment are equal to zero. Given this, the calculation of the IRR is not a particularly straight forward task.

Fortunately, Excel has in-built functions for it; the IRR and XIRR. As explained before in the NPV section above, we should use the XIRR formula as it handles cashflows that are not necessarily equally spaced with the same periodicity.

The XIRR formula is relatively straight forward:

XIRR(values, dates)

2.6.1 XIRR no. 1, 2 & 3

Unlike the XNPV function, the XIRR function can only be calculated correctly when the first cashflow (i.e. CF_0) is a negative number. This is because the XIRR function is reliant on the basic investment premises of an initial outlay before future returns.

Thus, you will notice the following (**Calcs**):

- XIRR no. 1: the XIRR is calculated from column H and returns an accurate value as the first cashflow (*H17*) so happens to be a negative number. Please note that while very accurate this does not represent the truest answer.
- XIRR no. 2: the XIRR calculation returns an erroneous zero as the first cashflow (*G43*) is not a negative number (zero in this case).
- XIRR no. 3: this is the best approach to calculating the XIRR and is achieved by inserting a very small negative number in period 1. This ensures that calculations are evaluated from column G and the very small number is small enough that it does not affect the IRR output.

Lastly, as a check that the IRR has been calculated correctly, calculating the NPV using the IRR as the discount rate should return a zero – *E47*

| | A | B | C | D | E |
|----|--------------------------------|---|----------|--------|---|
| 1 | Calculations | | | | |
| 2 | Tutorial: NPV & IRR | | | | |
| 3 | Period end | | Date | | |
| 41 | <hr/> | | | | |
| 42 | IRR | | | | |
| 43 | XIRR no. 1 | | % p.a | 30.19% | |
| 44 | XIRR no. 2 | | % p.a | 0.00% | |
| 45 | XIRR no. 3 | | % p.a | 30.19% | |
| 46 | | | | | |
| 47 | XNPV (vs. XIRR) check | | AUD '000 | 0.00 | |