The investment decision process

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Abstract

How to estimate investment projects cash flows and use those to calculate various performance measures used in the decision process.

Keywords: investment, project, NPV, IRR

Contents

Learning Objectives

By the end of this module, students should be able to:

- List the different kind of cash flows related to investment projects
- Actually perform the cash flows estimation from activity forecasts
- Calculate the net present value (NPV) of an investment project
- Adjust the NPV to take into account various constraints such as constrained resources or mutually exclusive projects
- Discuss the investment decision process, the biases to avoid and the good practices

1   The concept of an investment project

Definition: Investing

Investing is the process by which some resources are used to acquire fixed assets with the objective of using these assets to generate cash flows over some future periods of time.

This simple definition actually stresses the most important aspects of investment activities:

- investing implies spending resources, and all resources have a cost (see the chapter "The weighted average cost of capital"[1]),
- investing is not consuming: one invests in *fixed assets*, in order to use those and generate cash flows,
- the exact nature of the assets is irrelevant here: one can buy a computer, build a factory, buy some shares of stock or acquire a competitor, all this is investing,
- the cash flows are expected over different future periods: *time value of money techniques* will be used to deal with the time dimension.

In this context, an investment project is a set of related investments which form a standalone and consistent unit. Ideally, and investment project can be seen in isolation from the rest of the company: it is bounded. Clearly defining the boundaries of a project is important as it allows to consider all its (and only its) consequences and implications in order to make a decision about it.

One must especially make sure to include in the project all its dependencies: if one project implies this and that, then this and that are actually part of the project.

The decision process about investment projects is included in the general process knows as *capital budgeting*, that is, the process of investment management, from searching new projects to the control of projects performance *ex-post*. This is a tremendously important process for any company: in a way, a company might be seen as an "investing machine", and the balance sheet as a summary: the liabilities side tells the origin of the resources which were invested so far, and the assets side shows where they were invested.

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[1]https://files.bagneris.net/

2 Cash flows estimation

As defined above, investing might be seen as exchanging immediate resources for future expected cash flows. Besides, an investment project value – like the value of any asset – is the present value of all the cash flows it will provide in the future. From these two propositions follows that one has to estimate the (future, expected, unknown) cash flows of a project in order to calculate the project's contribution to the company's value, which in turn is an important criteria for the investment decision.

The cash flow estimation is based on forecasts, and forecasting is a difficult activity, which result come with uncertainty (risk). Depending on the size (how much money is needed) and the nature of the project, one will chose to be more or less careful and conservative in the estimation process.

A common classification of investment projects, from the simplest to the most involved in the estimation process, is:

- replacement projects: a machine is broken, it has to be replaced,
- regulatory or compulsory projects: projects which are required by external stakeholders such as governments or local authorities,
- expansion projects: the company develops in its core activities and markets,
- diversification: the company starts developing in previously unexplored activities,
- other high risk projects such as research and development, disruptive techniques adoption, major change in the company's core activities.

2.1 General principles of cash flows estimation

Because the contribution of the project ot the company's value will be measured as a present value, one must use a **sequence of cash flows** as an input to the present value calculation.

Note that earnings measured using bookkeeping or accounting principles are not cash flows and thus not suitable "as-is" for investment purposes. The reason is twofold:

- those earnings typically include some non-cash expenses such as the annual depreciation of assets,
- bookkeeping generally involves recording revenues and expenses before the underlying amount of cash is actually received or paid.

The decision process focuses on an investment project as a basis, that is, the decision is about one given project. Thus, all the cash flows of the project, but only the cash flows of the project must be estimated. A common method is to measure *incremental cash flows*. An incremental cash flow is the difference between the cash flow the company would receive if it invested in the project, and the cash flow it would receive if it did not.

As taxes should be paid and thus involve a cash expense, all cash flows should be measured after tax. Note that it is generally assumed that the company is profitable besides the new project, and thus, pays taxes. This is important to remember as this explains why "negative taxes" might sometimes appear in the cash flows calculations. These negative taxes are actually tax savings: if the project incurs a loss for a given time period, this will contribute negatively to (i.e. *reduce*) the total taxes the company will have to pay over this period.

As the cash flows will be discounted (in the present value calculation process) at a discount rate which is based on the cost of the resources, this rate already includes inflation anticipation. Thus, the cash flows

Year	1	2	3	4	5
Sales	600	3,000	5,000	8,000	4,000

Table 1: Estimated sales ($'000) on the Global Company project

should be measured inflation included. In addition, because inflation usually has different effects on the various cash flow components (revenues and expenses), deflating the cash flows globally often yields to bad estimations.

The cash flows should be measured independently of the investment financing: all financing costs should be ignored. This is because the cost of financing is taken into account through the present value calculation, which, again, involves discounting at the cost of the resources. This procedure is far more sound on theoretical grounds, and in addition, it allows to measure the "economic" cash flows of the project, estimating its performance whatever the financing which will finally be chosen – usually *after* the investment decision process.

All projects start by the investment process, buying assets, building factories, installing machinery, etc. Then comes the time the project "lives" and operations will last for a given number of years (sometimes refered to as the *time horizon* or *life* of the project, after which the project comes to an end for whatever reason: new technologies make it obsolete, new products replace it, … The cash flows will thus be grouped according to these different periods:

- cash flows related to the initial investment outlay,
- cash flows from the operations during the project life,
- end of project or end of forecasting period cash flows.

Finally, as the cash flows are estimated from activity forecasts, one can use any of the classical methods for dealing with uncertainty, such as:

- decision trees,
- scenarii building,
- Monte-Carlo simulations,
- sensitivity analysis,

and more. Nothing prevents you to use any of the available methods, provided you do so accurately, and you remember that in the end, the cash flows will be discounted at a rate that includes a risk premium.

The rest of this document will use a single and global example that is introduced below.

> **Example 1: The Global Company**
>
> The Global Company is producing and selling network appliances (switches, routers, WiFi access points, etc.) for professionals. It is considering developing a new range of products for the general public (homes and small offices), using its experience to provide affordable products without compromising on the general quality and security of those.
>
> The investment project would entail the development of a new production building near the company's main premises. A piece of land was bought a few years ago for a project which was finally cancelled, and is available.
>
> The sales estimates for the next five years are summarized in table 1, according to a preliminary market study.

> The cost and control department added the following information: the cost of goods sold (COGS) for that kind of appliances is estimated to 34% of sales, and sales, general and administrative costs are 5% plus a fixed part of $80,000. The net working capital is 20 days of sales (that is, 20 days out of a basis of 360 days per year).
>
> You might consider that the project will be abandoned after 5 years: machinery and equipments will be scrapped, and it is estimated that the land and building might be sold at that time.
>
> The Global Company's marginal tax rate is 28% and its weighted average cost of capital is 9.2%.

The full example is available online[2] on Google Spreadsheet[3].

2.2   Investment cash flows: initial outlay

The investment cash flow is the amount of money that the company has to spend (invest) in order to buy the assets which are necessary for the project: land, buildings, machinery, licences, whatever assets are needed to "start working".

As it is a cash outflow (an outlay or expense), the associated sum in the calculation will be negative.

The assets should be available before the company starts to operate the project, thus the investment cash outflow is generally considered to be spent at "time zero", that is, as soon as the decision is taken. It might happen, though, that setting up the assets takes some time: building a factory for example. The related expenses might then be spread over more than one period. Note that usually the actual operations start once the process of building the assets is complete.

Calculating the investment cash flow is as simple as adding all the investment expenses. Two cases request special attention and treatment:

- sunk costs,
- opportunity costs of existing assets.

Sunk costs

Sunk costs are costs that are associated to the project, but were already paid at the time the investment decision has to be taken. This is often the case of preliminary research or market studies. These sunk costs *should not be included* in the investment outflow. The reason is that they are no longer relevant for the decision at stake. Remember that we measure incremental cash flows, by making the difference between the sequence of cash flows if the company invests and the sequence of cash flows if it does not. As the sunk costs were paid already, whatever the decision, they do not make any difference in the sequence of cash flows.

Opportunity costs of existing assets

What should be done if the company plans to use for the project an asset it owns already? As the asset is already the company's property, there is no cash expense associated with it. But if the asset is available for the project, that means it is available for other purposes as well: there might be an *opportunity cost* associated with it. A very common example is that if the asset is not used for the project, it might be sold for a given price: the opportunity cost is then the (after tax) price at which the asset would have been sold if the company did not use it for the project. Again, the key is the incremental cash flow, the

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[2]Note that you cannot edit directly the spreadsheet online: you should download it and work on your local version.
[3]https://docs.google.com/spreadsheets/d/1P0t7DBQrc3Mhx16Apds2k974RCxJCGO3YngltUCe7pk/

difference between the cash flows if the company invests (it does not receive the price as it does not sell the asset) and the cash flows it it does not invest (it receives the price and pays the associate taxes, if any).

Note 1: After tax cash flow resulting from selling an asset

Selling some fixed asset usually implies two cash flows:

- a cash inflow which is the price paid by the buyer for the asset,
- some taxes (or tax savings) to be paid (saved) on the capital gain (loss) realized by selling the asset.

The capital gain or loss is the difference between the sell price of the asset, and its book value in the company balance sheet at the time it is sold. In order to calculate the book value, one subtract the depreciation expenses so far (if any: land usually does not depreciates) from the buying price of the asset.

The capital gain or loss is then multiplied by the appropriate tax rate, and the resulting tax or tax savings is combined with the sell price to get the after-tax cash flow from selling the asset.

The table below summarizes the different steps:

P	=	Sell price
	-	Book value
	=	Capital gain or loss
	×	Tax rate
T	=	Tax or tax savings
P - T		After tax cash flow

See the example below for an application.

Example 2: The Global Company - Investment cash flow

We need more details about the assets needed for the Global Company project: the cost of the new production building and the related amenities, and information about the piece of land the company is planning to use.

The department in charge of the new building informs that the building itself will cost $3.5 million and will be depreciated to zero over 20 years on a straight line basis. The various equipments and machinery will cost an additional $0.8 million, depreciated straight line to zero over 5 years.

About the land, the company has been informed that it might be sold for an estimated $1.2 million. It was bought for $0.9 million three years ago.

Finally, the preliminary market study which provided the sales figure in table 1 costed $35,000.

Whith the above information, we have to calculate the total investment cash outflow, taking care of opportunity costs and avoiding sunk costs, if any.

First we simply add the known investment expenses: $3.5 for the building and $0.8 for equipments and machinery, getting a total of $4.3 million.

About the land, there is an obvious opportunity cost, as it can be sold if it is not used in the investment project: investing will make the company loss the opportunity of selling the land at $1.2 million. Note that this is the opportunity cost before taxes. We assume that, if it sold the land, the company would have to pay taxes on the capital gain it would make, that is, the difference between its sell price and its book value. As land does not depreciate, the book value here is the initial price the company paid, $0.9 million. We can calculate the after tax opportunity cost by using the above method to get the after tax cash flow from selling an asset:

P	=	Sell price	1.200
	-	Book value	0.900
	=	Capital gain or loss	0.300
	×	Tax rate	0.28
T	=	Tax or tax savings	0.084
P - T		After tax cash flow	1.116

So the final opportunity cost is $1.116 million.

Finally, the market study was paid already: investing now or forgetting the project does not make any difference about it. This is a typical sunk cost.

The total investment cash outflow is the sum of the investment in assets, $4.3 million, and the land opportunity cost, $1.116 million:

$$4.3 + 1.116 = 5.416$$

2.3 Operating cash flows: running the project

The operating cash flows are the cash flows the company will get from operating the project until the end of its economical life, the time horizon.

According to the general principles of cash flows estimation above, we should calculate incremental cash flows (that is, the additional cash flow the project would bring to the company), excluding cash flows related to the financing (which is supposed to be undecided yet and will be taken into account through discounting), and including taxes.

The activity forecasts related to the project are commonly provided as sales estimates, that is, the sequence of additional sales (turnover) the project is supposed to generate over the years.

From the sales, the first step is to calculate the EBITDA (Earnings Before Interests, Taxes, Depreciation and Amortization) by subtracting the cash expenses related to the operations. These might be given as fixed and variable costs, or COGS (Cost Of Goods Sold) and SGA (Sales, General and Administrative costs), or something different, but the idea is always the same: remove the costs related to the operations, excluding of course depreciation and amortization which are not cash expenses.

Once the EBITDA is calculated, one should remove the additional taxes the company will have to pay because of the project (or add tax savings, if any). This implies the calculation of the EBT (Earnings Before Taxes) from the EBITDA, by subtracting depreciation and amortization of the project's assets. But remember that the EBT is an artifact of calculation, not a cash flow.

Finally, to take into account various time effects such as delayed payments, one should remove the an-

nual increase of the NWC (Net Working Capital). As the cash flows are calculated per period (usually per year), and the NWC increases gradually, one should decide when to subtract its increase: in the beginning or in the end of the period? As sales and costs are totally acquired in the end of the period, the question is thus, should the increase in NWC from period n-1 to period n be subtracted from the EBITDA of n, or the EBITDA of n-1? It sounds reasonable to consider that the cash needed to finance the increase in the NWC of the period should be available at the beginning of the period, that is, the end of the previous one.

Note 2: Why anticipate on the NWC increase

Another rationale for anticipating on the net working capital increase is to consider what is necessary to really start operations on a new project.

Assume (without loss of generality) an industrial project: the company makes the final product by transforming raw material on machinery. To start the project, it needs first the machinery: this is the investment itself, the initial outlay in fixed assets at time zero. But then, to start working, it also needs raw material, that is, it needs to spend some resources in inventories *before* the projects starts, again, at time zero. This inventories are of course part of the net working capital related to the project[a], and the need to create this inventories of raw materials is a part of the NWC increase related to the project.

As you see, here, the increase of the NWC should actually be spent in the beginning of period one, thus at time zero. It adds to the investment in fixed assets to form the total outlay necessary to start the project.

All this is of course related to the periods length in the cash flows table (granularity). If the time period is, as often, one year, what does it mean to put a figure in the "Year 1" column? Take the sales, for example. When exactly is this amount of sales realized? In the beginning, the middle, or the end of the year? The answer is that the sales of one year accumulate gradually along the year, but what is important to us is that *it is only on the last day of the year* that the whole figure is indeed realized. Thus, putting this figure in the same column as the spending in raw material which, conversely, should be done *on the first day of the year* sounds unreasonable: we thus put the increase of the NWC in the previous column, to take into account this one year difference.

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[a]The main components of the Net Working Capital are inventories, receivables and payables.

The final calculation of the cash flow of a given period is thus:

$$CF_n = EBITDA_n - Taxes_n - \left(NWC_{n+1} - NWC_n \right) \tag{1}$$

Example 3: The Global Company - Operating Cash Flows

Table 2 shows the various steps for the calculation of the project cash flows from year 0 to year 5. Note that all figures are in thousands ($'000).

Comments:

- Sales: as given in table 1
- COGS: 34% of sales
- SGA variable: 5% of sales

Year	0	1	2	3	4	5
Sales		600	3,000	5,000	8,000	4,000
COGS		204	1,020	1,700	2,720	1,360
SGA fixed		80	80	80	80	80
SGA variable		30	150	250	400	200
EBITDA		286	1,750	2,970	4,800	2,360
Depreciation		335	335	335	335	335
EBT		-49	1,415	2,635	4,465	2,025
Taxes		-14	396	738	1,250	567
NWC		33	167	278	444	222
Increase in NWC	33	133	111	167	-222	-222
Operating cash flow	-33	166	1,243	2,066	3,772	2,015

Table 2: Operating cash flows ($'000) of the Global Company project

- EBITDA = Sales - COGS - SGA fixed - SGA variable
- Depreciation = (3,500 / 20) Building + (800 / 5) Equipments and machinery
- EBT = EBITDA - Depreciation
- Taxes = 28% of EBT. When EBT is negative, it reduces the global EBT of the company and thus entails tax savings (negative taxes)
- NWC = Sales $\times$ 20 / 360
- Increase in NWC = $NWC_n - NWC_{n-1}$
- Operating cash flow = EBITDA - Taxes - Increase in NWC

2.4   Divestment cash flows: ending the project

All projects have a *time horizon*: first because nothing lasts forever in the business world, and second because, whatever the actual length of the project, the number of future periods for which we can get reasonable forecasts is limited to a few years at best.

Thus we have to deal with the "end of the project", or, more precisely, with the last column of the cash flows table. If the project comes to an end, this has certainly financial consequences, and if it carries on beyond the forecasting period, the value of the cash flows after this point should be estimated.

End of the project

If the project comes to an end, this usually implies cash flows related to its termination. These cash flows can be cash inflows and/or cash outflows. Cash outflows examples are the costs of destroying a building, cleaning a piece of land etc. Cash inflows might be the result of selling the project's assets, which might no longer be needed once it stops.

The case of selling the assets is quite common, and the resulting cash flow is sometimes called "divestment cash flow" or "terminal year after tax non-operating cash flow" (TNOCF). It is calculated using the method exposed above in the "After tax cash flow resulting from selling an asset" box, p.6.

			Machinery and equipment	Land and building
P	=	Sell price	0	2,000
	-	Book value	0	3,525
	=	Capital gain or loss	0	-1,525
	×	Tax rate	0.28	0.28
T	=	Tax or tax savings	0	- 427
P - T		After tax cash flow	0	2,427

Table 3: Divestment cash flow ($'000) of the Global Company project

Project continuation

If the project carries on beyond the time horizon, the cash flows beyond this point will be replaced with a global value, usually known as "residual value".

How is this better (or easier) than extending the table for more periods? It is simpler because instead of estimating the cash flows of the future years one by one, which is probably less and less realistic, one only has to estimate a global value.

The residual value is often calculated by capitalizing the last cash flow forever or for a given number of years, with or without a growth or decline.

Example 4: The Global Company - Divestment

The Global Company investment project will come to an end after 5 years: we are told that it will be abandoned, and the machinery and equipment will be scrapped.

Regarding the land and the building, it is estimated the might be sold in the end of the 5 years. Requesting additional information, we learnt that a reasonable selling price is $2 million for the land and the building on it.

All the information needed to calculate the total divestment cash flow is now available. The result is $2,427,000 and the details of the calculation are shown in table 3. Note that scrapped assets have a "sell price" of zero here, but it might as well *cost money* to get rid of those in the real life.

The total book value of the land and building is calculated this way:

- the land was bought for $900,000, and land is not depreciated, thus its book value is $900,000
- the building was bought for $3,500,000 and is depreciated over 20 years straight line to zero, thus $175,000 per year. In the end of year 5, its book value is then

$$3,500,000 - (5 \times 175,000) = 2,625,000$$

The total book value of the land and the building is finally:

$$900,000 + 2,625,000 = 3,525,000$$

3 Project valuation, projects interactions and constraints

Once the series of forecasted cash flows is ready and available, the next step is to aggregate it to calculate a single value for the project. The resulting amount represents how much value the project would add to the company (or destroy, if it is negative), and is called the *Net Present Value* or NPV.

3.1 Project valuation: the Net Present Value

As the name suggests, the net present value is a present value, that is, the discounted value of the project's cash flows. It is called net present value because the future (operating and divestment) cash flows are generally cash inflows, and the investment itself is a cash outflow. The net present value is then the present value of all the future cash flows, *net of* (minus) the necessary investment outlay to get those.

Discounting the cash flows ensures that the whole process takes into account two very important factors, the timing of the cash flows, and the company's cost of resources.

The timing of the cash flows cannot be ignored, as the fact that the date at which a given cash flow is paid or received matters: one prefers to receive early and pay late (see the chapter on "Time value of money"[4]). The discounting process uses the period number to increase the weight of the discounting factor.

The cost of the company resources, measured by the WACC, is generally the appropriate discount rate for investment purposes, known as the *required rate of return* on the investment project. This allows to take into account the cost of the financing, which was deliberately ignored in the cash flows estimation. Again, this is far better than trying to estimate the exact cost of financing a given project period after period.

Even if the proposed financing for a given project is known in advance, that is, before the final decision (invest or not) is decided, calculating the cash flows related to this financing is less simple than it seems.

Imagine that *x*% of the project will be financed by a specific loan: it is then easy to find the cash flows related to the loan. But what about the remaining 100 - *x*%? If it is not debt, then it is equity financing. What are the cash flows associated with equity financing? As we know, dividends are not the only source of return to the shareholders. And even if there were only dividends, which proportion of those should be attributed to the project? How do we estimate the future dividends the company would pay over the project's life? How do we measure the projects weight (importance) in the company? Should the book value of its assets be used? Or the market value? How to calculate the market value of these assets over the different periods?

And finally, remember that discounting is necessary to take into account the timing of the cash flows. How would we do that if we do not discount because the cost of the resources is in the cash flows?

NPV Calculation

Calculating the NPV is straightforward: take the sum of the discounted cash flows, using the WACC as a discount rate for the most common cases (see below).

Written as a formula, the above proposition yields:

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[4]https://files.bagneris.net/

Year	0	1	2	3	4	5
Investment cash flow	-5,416					
Operating cash flows	-33	166	1,243	2,066	3,772	2,015
Divestment cash flow						2,427
Total cash flows	-5,449	166	1,243	2,066	3,772	4,442
Discounted cash flows	-5,449	152	1,042	1,586	2,653	2,861
NPV	2,845					

Table 4: Net Present Value ($'000) of the Global Company project

$$\text{NPV} = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t} = CF_0 + \frac{CF_1}{(1+r)} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n} \qquad (2)$$

with CF_t the cash flow for period t, n the total number of periods and r the discount rate, which, again, is generally the WACC of the company.

Note 3: When is the WACC not the appropriate discount rate?

The Weighted Average Cost of Capital of the company depends on the risk taken by the resources providers: the higher the risk, the higher the cost of the resources (again, see the chapter "The Weighted Average Cost of Capital").

Most investment projects of a company belong to its main activity or core business, and as such, bear the same risk level as the company as a whole. The WACC is then an appropriate discount rate for the NPV calculation.

But if an investment project bears another level of risk, different from the global one, then a specific required rate of return should be used for discounting purposes. The calculation of that kind of rate goes beyond the scope of this document, see the references in the Going further section.

Example 5: The Global Company - NPV Calculation

To calculate the NPV of The Global Company's project, we proceed in three steps:

- get the total of the investment, operating and divestment cash flows for each period (remembering that the investment cash flow is in year 0 only, and the divestment in year 5 only)
- discount the total cash flows at the Global Company's WACC, which is 9.2%
- add the discounted total cash flows to get the net present values.

The process is detailed in table 4 and is self explanatory.

Using equation 2 above yields of course the same result (in $'000):

$$-5,449 + \frac{166}{1.092} + \frac{1,243}{1.092^2} + \frac{2,066}{1,092^3} + \frac{3,772}{1.092^4} + \frac{4,442}{1.092^5} = 2,845$$

Once the NPV is available, a simplistic rule is to invest in the project when the NPV is zero or positive, as that means that the project is able to pay for the resources it uses, and, if the NPV is positive, adds value

to the company. Conversely, if the NPV is negative, the project should be ruled out because it destroys value.

The above rule ignores anything but one number (the NPV), which in addition is based on forecasts: there is far more to an investment project than a single number. A full section is dedicated to the decision process below. For now, let us simply consider the NPV as a rigorous estimation of the financial performance of a project.

The NPV is a robust and convenient measure as it is easy to calculate and provides a *value* (expressed in a given currency) as a result. As a consequence, NPVs can be added or subtracted without losing their meaning:

- the NPV of investing in both project A and project B is the sum of the two projects' NPVs.
- the NPV of investing in project A *rather than* in project B is the difference between the two project's NPV.

These properties are important to remember, and, as we will see below, they do not hold for other measures such as the internal rate of return or the payback period.

NPV

Calculates the net present value of an investment based on a series of periodic cash flows and a discount rate.

Sample Usage

```
NPV(0.08,200,250,300)
```

```
NPV(A2,A3,A4,A5)
```

Syntax

```
NPV(discount, cashflow1, [cashflow2, ...])
```

- `discount` - The discount rate of the investment over one period.
- `cashflow1` - The first future cash flow.
- `cashflow2, ...` - [OPTIONAL] - Additional future cash flows.

Figure 1: The NPV() function documentation

Note 4: Beware of the misleading NPV function in spreadsheets

Spreadsheet software is often used for calculations related to the investment decision: the tabular presentation and nearly instantaneous evaluation of the formulas make it really fitted for that kind of problems.

Still, you should know that the NPV() function of those tools has a misleading name: it does **not** calculate the NPV as defined above, but rather the present value of a series of cash flows: the first cash flow of the series is not the cash outflow at time zero, but the first *future* cash flow. Figure 1 shows an excerpt of the Google spreadsheet documentation: notice under the syntax section that `cashflow1` is indeed defined as the first *future* cash flow.

Thus, if you insist to use the NPV() function to calculate the NPV, don't forget to subtract the initial cash outflow of period zero to get the real NPV.

3.2   Adjusting the NPV, additional measures

Still, you probably heard about other so-called investment decision criteria, such as the internal rate of return (IRR) or the payback, to name the most (in)famous ones. To introduce these, we first discuss about the circumstances under which the NPV alone is not enough to get a correct *financial* overview of the project, and then, if/when those other measures can help. Finally, we tell a few words about a sanity check: the NPV break-even point.

Resources availability

Theoretically, in a world of perfect and efficient financial markets, companys can get resources in an unlimited fashion as long as they invest in positive NPV projects. This essentially means that the "size" of a given project does not matter, and that, unless projects are mutually exclusive, chosing is not necessary.

> **Example 6: The Global Company - Another project**
>
> Imagine that the Global Company is considering a second project, with an investment outlay of $500,000 and roughly the same NPV as the first project ($2,845,000). What should be done?
>
> In a perfect world, the fact that one should spend more than $5,000,000 in project one rather than $500,000 in project two, to get *the same NPV*, is not relevant: as both projects have a positive NPV, the company will find enough resources to invest in both projects. There is no point in comparing.

In the real world, markets are not perfects, (some) investors are (still) humans and thus introduce bias in their decisions. This might lead to limited resources availability for companies. Furthermore, most companies are organized in more or less independent departments or divisions, which are allocated periodic investment and expenses budgets[5], limiting *de facto* the amount of resources they can spend on their projects.

If resources are limited, one is of course concerned with the project *size*, the value of the initial outlay. An obvious way of taking it into account is to use relative values. The NPV is basically the difference between the present value of the future cash flows and the investment outlay: in order to get relative values, we make it a ratio, and divide the present value of the future cash flows by the (absolute) investment outlay. The result is called *profitability index* and can be used to order projects by "profitability", to allocate the company's limited resources to the most profitable ones first[6].

The profitability index formula is thus:

$$\text{IP} = \frac{\text{PV}}{abs(CF_0)} = 1 + \frac{\text{NPV}}{abs(CF_0)} \tag{3}$$

Where PV is the present value of all the future cash flows, starting with CF_1, the cash flow of the first period.

> **Example 7: The Global Company - Profitability Index**
>
> The Global Company project's NPV is $2,845,000, and we can read in table 4 that the cash outflow

---

[5]This is why the investment decision process is often called "capital budgeting".

[6]You might note that, because projects are seldom divisible, spending the resources by taking the projects in order is not always optimal if this leads to remaining, non invested resources.

Year	0	1	2	3	4	5
Investment cash flow	-5,416					
Operating cash flows	-22	79	1,155	1,978	3,684	1,916
Divestment cash flow						2,427
Total cash flows	-5,438	79	1,155	1,978	3,684	4,343
Discounted cash flows	-5,438	72	968	1,519	2,591	2,797
NPV	2,509					

Table 5: Cash flows and NPV ($'000) with the cannibalization effect

in period 0 is $5,549,000. Thus the profitability index of the project is:

$$\text{PI}_1 = 1 + \frac{2,845,000}{5,549,000} = 1.52$$

Note that if another project really existed with a $500,000 initial outlay, like in the previous example, its PI would be far better:

$$\text{PI}_2 = 1 + \frac{2,845,000}{500,000} = 6.69$$

Projects interactions

As much as we want to "isolate" an investment project in order to calculate its cash flows and profitability, we cannot ignore that it is initiated by a company, which has other activities and projects. Those will probably interact with the one we study, and the interactions should be taken into account.

Projects interactions can take many forms:

- complete independance,
- consequences on other activities, such as synergy or cannibalization,
- mutual exclusivity,
- total dependance.

When projects are totally independant, there is no special treatment to apply, except maybe to make sure that the company's WACC is the correct discount rate for the project: see the frame "when not to use the WACC".

Projects actually often have simple consequences with the other activities of the company, either positive (synergy) or negative (cannibalization, that is, transfer of sales from an existing project/activity to the new one). These effects should be included in the cash flows calculation.

Example 8: The Global Company - Effect on the Global Sales

The marketing department of the Global Company just warned you that a small proportion of industrial appliances sales actually come from the general public already. The estimate is that every year, around $200,000 of industrial appliances are sold to non-industrial customers. To take this into account, we should reduce the projects sales by the same amount avery year. So for example in year 1, following the incremental cash flows principle, we recognize that the project will bring $600,000 of

sales on the one side (table 1), and destroy $200,000 of sales of industrial appliances on the other side (these sales are "transfered" to the new range of products).

Table 5 shows the new cash flows and NPV resulting from the cannibalization effect – the reader is encouraged to check the details by himself. Assume that COGS and SGA are similar for the project and the other companies activities.

When two projects are mutually exclusive, there is no way the company can invest in both at the same time. It is not a problem of financial resources, but a practical one: both projects would use the same piece of land, for example.

An interesting and common case is the choice between two assets that would have the same purpose and utility, for example machines used for production. As the considered equipments have the same purpose, one can imagine that their effect on production (and sales) would be the same. Thus, following again the incremental cash flows principle, one would decide on the costs only, that is, with negative cash flows. One machine might use less energy, or its maintenance cost is lower than the other one, but the initial price higher… As the comparison is on the costs only, one would chose the "less negative" NPV (which actually is the mere present value of all the costs), that is, the cheapest asset once all costs have been considered.

But this case often leads to another problem: what if the economical lives of the assets we have to compare are not the same? How can we "correct" the NPV to include the fact that one will have to be replaced sooner than the other one?

The solution is to use the Equivalent Annual Cost (EAC). The logic is to "annualize" the present value of the costs for each project, and then to compare on the annualized costs. To annualize the present value of the costs we have to divide it by the sum of the discount factor over the life of the project.

Example 9: The Global Company - Equivalent Annual Cost

A machine used in the production process at the Global Company breaks unexpectedly and has to be replaced urgently. Note that this is not an "investment decision" as the company has no choice but to replace the missing machine. Still, there is a choice, as two providers propose suitable equipments. Table 6 shows the after tax cash outflows associated with each machine, including the initial investment outlay in year 0. Machine A should be scrapped and replaced after 3 years, whereas machine B would last 4 years.

We can calculate the present value of the after tax cash outflows for each machine, discounting the cash flows at the company's WACC:

$$\text{NPV}_A = -400 - \left[50 \times \frac{\left(1 - 1.092^{-3}\right)}{0.092} \right] = -526$$

$$\text{NPV}_B = -400 - \left[45 \times \frac{\left(1 - 1.092^{-4}\right)}{0.092} \right] = -545$$

It seems that Machine A is slightly less costly, but remember that we would have to replace it earlier than Machine B. Let us include the "time dimension" by calculating the equivalent annual cost for

Year	0	1	2	3	4
Machine A	-400	-50	-50	-50	
Machine B	-400	-45	-45	-45	-45

Table 6: Cash outflows ($'000) of the proposed machines

each machine:

$$\text{EAC}_A = \frac{-526}{\frac{(1-1.092^{-3})}{0.092}} = -209$$

$$\text{EAC}_B = \frac{-545}{\frac{(1-1.092^{-4})}{0.092}} = -169$$

Machine B has the lowest annual cost.

It should be noted that using the equivalent annual cost technique assumes that the equipments considered can be renewed at the same conditions (investment and costs) once they come to an end.

Finally, when projects are completely dependant or linked, that is, project one *implies* project two, and project two *depends on* project one, then they should be studied together: they actually form one and only one project.

The Internal Rate of Return (IRR)

The internal rate of return (IRR) calculation is based on the same data than the one used for the net present value, the series of all the project's cash flows. For this reason, some consider it is as good a measure as the NPV, and that NPV and IRR can be used in an undifferentiated manner. *This is absolutely not true*. IRR and NPV are totally different measures and, in particular, can lead to a different ranking of projects – and yes, the correct ranking is the one provided by the NPV. To see why, we first define the IRR and then discuss its problems and limits.

The IRR is the discount rate which would make the sum of the discounted cash flows equal to zero. That is why it is called "internal" rate of return: the calculation only uses the inner data of the project, and, specifically, ignores the company's cost of resources, which might be considered as external to the project.

The IRR suffers from many limitations, either specific to its definition, or related to the investment decision context, which make it difficult (and probably dangerous) to use if one does not really understand it.

The problems specific to the IRR itself and its definition are:

- There is no "formula" to calculate it directly, but rather a process. This process neither ensures that a solution exists, nor that the solution is unique. It all depends on the series of cash flows.

- The "rate of return" part of the IRR name is misleading: this is not necessary the rate of return you would get if you invest in the project, as it assumes that the cash flows received at each period are immediately re-invested at the IRR itself for the remaining periods.

- The IRR is a rate, not a value. As such, one cannot add, subtract or combine (average) internal rates of return of multiple projects.
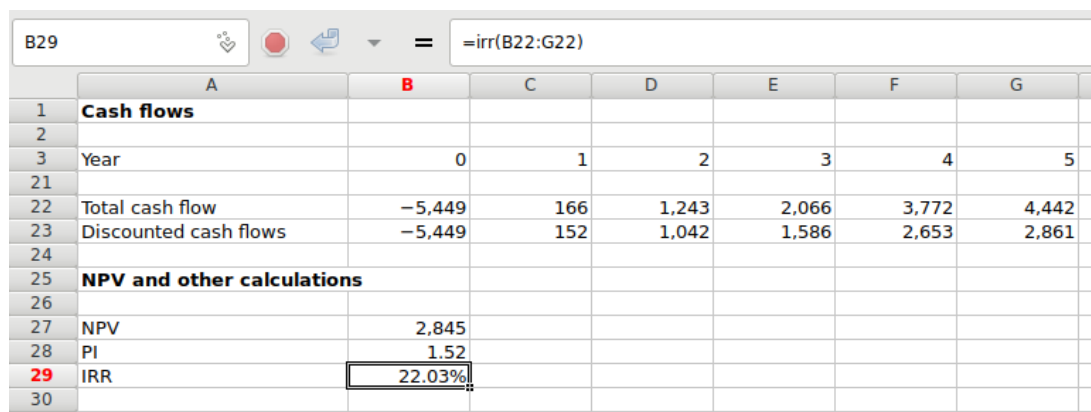
In the investment decision context, the problem is of course that the IRR calculation ignores the cost of the company resources (the WACC). This means that if you rank different projects according to their IRR,

it is as if *you valuated each project with a different discount rate*. I cannot imagine any justification for this, and again, never ever do that, it is just plain wrong.

Example 10: The Global Company - Internal Rate of Return

To calculate the IRR over a series of cash flows, the simplest way is to use the IRR() function of spreadsheets. Figure 2 shows the calculation for the Global Company. Note the formula, the IRR() function is used on the series of total cash flows, from cell B22 to cell G22.

Here the IRR is 22.03%. It is greater than the company's WACC, which means that the project is profitable (if the cash flows forecasts are accurate of course), and adds value to the company. We knew all this already from the NPV, which actually tells us more as it measures *how much* value.

	A	B	C	D	E	F	G
			=irr(B22:G22)				
1	Cash flows						
2							
3	Year	0	1	2	3	4	5
21							
22	Total cash flow	−5,449	166	1,243	2,066	3,772	4,442
23	Discounted cash flows	−5,449	152	1,042	1,586	2,653	2,861
24							
25	NPV and other calculations						
26							
27	NPV	2,845					
28	PI	1.52					
29	IRR	22.03%					
30							

Figure 2: IRR calculation on a spreadsheet

Finally, should you use the IRR in the investment decision process? Probably not. If you search the internet for cases of using the IRR instead of the NPV, you will of course find a lot: all are flawed in one way or another. For example, some argue that IRR is better than NPV because "NPV uses arbitrary discount rates". If you read so far, you know that the discount rate is not arbitrary: it is the relevant cost of the resources which would be invested in the project. Furthermore, even if you do not need a discount rate to calculate the IRR, when it comes to the decision, you will have to compare the IRR to something: is x% a good enough rate or return for our project? There, you need an "arbitrary rate" too, it seems.

The payback period

Another quite common measure regarding investment projects is called the payback period. The idea is quite simple: how many periods of cash flows should the company accumulate in order to recover the initial outlay at time zero?

Again, we do not measure a value here, and again, we cannot combine the results (paybacks): the payback of two projects is not the sum or the average of the projects' paybacks, the payback of this project rather than that one is not the difference of their paybacks. But the main problem with the payback is of course that it ignores all the cash flows that follow (are expected to be received after) the payback period.

The payback should never be used as a standalone criteria, either to decide about a given project (how to define the acceptable range for the payback?), or to rank projects (as it ignores some cash flows by design, thus the ranking would be biased). Nonetheless, the payback might be used in addition to the

Year	0	1	2	3	4	5
Total cash flows	-5,449	166	1,243	2,066	3,772	4,442
Accumulated cash flows	-5,449	-5,283	-4,040	-1,975	1,797	6,240

Table 7: Accumulated Cash Flows ($'000) of the Global Company project

present value, as it gives an idea of the "speed" at which cash is generated by a given project. Note that the NPV also captures this time dimension, through discounting, but this is maybe less obvious.

Example 11: The Global Company - Payback

To calculate the payback, simply accumulate the cash flows over the periods, starting at time zero. When the accumulated cash flows start to be positive, the payback period has been reached. Table 7 displays the accumulated cash flows for the Global Company's project: as you can see, the payback period is some time in the third year, roughly three years and a half.

Sanity check: the NPV break-even

Forecasting is a very difficult task, and truth is, we seldom get it right, and when we do, we tend to underestimate the part of luck in the process.

One good safeguard to have when you forecast something is a *safety margin*: the relative amount of error on your forecast that would not change whatever conclusion you came to.

In the investment decision process, that means that we want to calculate the minimum (average) operating cash flow per period, that is, the periodic operating cash flow that would provide the minimum acceptable NPV, zero.

The greater the difference between the cash flows we forecasted and the minimum one, the safer we are, because it allows for greater errors in the forecasts.

Note that once you have the minimum acceptable cash flow, it is straightforward to get the level of sales that would ensure it, which is of course more consistent with the idea of a break-even point.

Example 12: The Global Company - NPV break-even

Let us calculate the minimum average operating cash flow needed to get a zero NPV on the Global Company's project. The investment cash flow and the divestment one do not depend on the level of activity: we simply report those in the NPV formula. We neglect the increase in NWC in year zero for the sake of simplicity. The unknown operating cash flow we are looking for is *X* in the formula:

$$-5,416 + \frac{X}{1.092^1} + \frac{X}{1.092^2} + \ldots + \frac{(X + 2,427)}{1.092^5} = 0$$

In the above formula, all the *X*s form a constant annuity over the 5 years, so we can apply the short-cut for the present value of a constant annuity:

$$-5,416 + \left(X \times \frac{(1 - 1.092^{-5})}{0.092} \right) + \frac{2,427}{1.092^5} = 0$$

Finally:

$$X = \left(5,416 - \frac{2,427}{1.092^5}\right) \times \frac{0.092}{\left(1 - 1.092^{-5}\right)} = 996$$

The average *forecasted* operating cash flow is

$$\frac{\left(166 + 1,243 + 2,066 + 3,772 + 2,015\right)}{5} = 1,852$$

Here the safety margin is quite important, as the minimum average cash flow is roughly 54% only of the average forecasted cash flow.

4   A few words about the decision process

Once the cash flows have been determined and the NPV and derived measures have been calculated comes the decision time. The question to answer might generally take two forms:

- should the company invest in this project?
- given the set of available projects, in which projects should the company invest?

Note that these are not the only possible questions, others, more complex questions may arise, such as "when is it optimal to invest in this project?".

It might seem straightforward to answer these questions, given the calculations and tools introduced above: invest in the project if and only if its NPV is positive, chose the projects with the highest profitability index first etc.

This would ignore completely the fact that a project is a complex artifact, with many aspects beyond the mere financial measures, such as law, environment, human resources, industrial, and other aspects. The cash flows and the NPV are only (probably relevant) data, not final answers. *Decision is a process* and it should take into account all relevant information. Most companies have (or should have) a set of clearly defined procedures for any decision process, and investment is no exception here.

4.1   Biases

When it comes to deciding about something, the human behaviour is affected by bias which have been studied for a few years now in such fields as behavioural economics and behavioural finance. The point is stop assuming that all agents are perfectly rational when taking decisions.

Two biases are particularly common when it comes to the investment decision.

Firstly, it often happens that the more carefully one estimates forecasts, the more one is induced in believing they are "true". They are not. Forecasts are mere educated guesses about a future we do not know, and should be taken as such. One important consequence is that no single figure in your spreadsheet is engraved in stone and definitive. There must be a revision and refinement process, which allows to correct the figures as time passes, monitor the project and its outcomes, and take further decisions when this is possible (see "Flexibility and options" below).

Secondly, it is very common that people meet to take a decision about a project to see someone reporting on the project, maybe showing slides or passing around a full written report. The problem is that more

often than not, the people reporting about the project are its proponents, because they are the one who studied it in detail. That is ok as long as another point of view is also presented during the meeting – which is seldom the case. There must be some kind of contradiction, some advocacy *against* the project shown, otherwise the decision will be biased in favor of the project, even if its proponents showed their points in good faith.

4.2   Flexibility and options

Most projects include some kind of options, and these options have a value, which should not be forgotten during the decision. Some models exist to value these options, they go beyond this simple introduction, but the options of a project should at least be known and taken into account in the decision process.

Most options are related to some flexibility in the project management. Some common options include:

- the option to delay a project (invest later rather than now),
- the abandonment option: stop a project early if the outcome is not as expected,
- the extension option: develop a project if it is successful,
- flexibility options in the production and selling process: externalize part of the production process, modify the delivery, pricing etc. of the products.

Summary

- Investing is spending resources in fixed assets in order to use these assets to generate future cash flows.
- An investment project is a standalone and consistent set of related investments.
- There are 3 kinds of cash flows expected on an investment project: the initial cash outflow or investment cash flow, the operating cash flows over the life of the project, and the end of project or divestment cash flow.
- To correctly estimate the cash flows, one should measure incremental cash flows, include inflation and taxes, and exclude all cash flows related to the financing of the project.
- The investment cash flow should include the opportunity cost, but exclude the sunk costs.
- The operating cash flows are calculated by subtracting the additional taxes and increase of the net working capital from the additional EBITDA provided by the project.
- The divestment cash flow is often (but not always) the after tax cash flow resulting from selling the projects assets once it comes to an end.
- The cash flows are then used to calculate the Net Present Value by discounting those at an appropriate discount rate: the WACC, or a specific rate for the project if necessary.
- Various extensions to the NPV, such as the profitability index or the annual equivalent cost might be calculated to take into account some common constraints.
- The internal rate of return and the payback both suffer from severe flaws and should generally be avoided in the investment decision context.
- Calculating the NPV break-even allows to estimate the safety margin on the cash flow forecasts: it is strongly advised to do it for all projects.
- The decision is a process, and NPV and cash flows are merely additional data to be considered in the process. Beware of common decisions bias such as overconfidence in the forecasts, or single-sided point of view in the process.
- Most project have options which have a value and should be considered in the decision process.

Exercises

Provide all answers with 2 decimal places. Remember to round the final result only: you should never round any intermediary result.

1. Consider a project by which a company would get 3,000 of additional sales every year for 5 years. The necessary investment in fixed assets would be 4,500, depreciated straight line to zero over the 5 years. The assets would be worthless in the end of the project. Operating costs are 36% of sales, and fixed costs of 430 per year. The additional net working capital is negligible. The marginal tax rate of the company is 28%.

   - What is the operating cash flow expected every year from the project?
   - Using a 10.6% discount rate, calculate the project's NPV
   - What is the NPV break-even cash flow of the project?
   - Which amount of sales would be necessary to get the NPV break-even cash flow?

2. Table 8 shows the EBITDA forecasts for an investment project. The investment in fixed assets would be 3,400 depreciated to zero over 4 years. It is estimated that the assets might be sold for 420 in the end of the project. The net working capital would amount to 8% of the EBITDA and the tax rate is 1/3. Assume that the required discount rate is 9.4%. What is the NPV of this project? Its profitability index?

3. A company has to replace a float of delivery vehicles and is considering two options:

   - buying the vehicles. The total price would be 200,000, the servicing would cost 15,000 per year, the vehicles would be depreciated straight line to zero over 3 years. They would actually be worthless and have to be replaced every three years.
   - renting the vehicles. The cost would be 80,000 per year, servicing included.

   You might assume that both options are renewable without any change in the future. All costs are before tax, the marginal tax rate is 30% and the required rate of return 11%. Which option has the lowest annual cost?

Year	1	2	3	4	5
EBITDA	820	1,600	2,200	2,200	1,800

Table 8: Exercise 2 EBITDA Forecasts

Exercises answers

1. Consider a project by which a company would get 3,000 of additional sales every year for 5 years. The necessary investment in assets would be 4,500, depreciated straight line to zero over the 5 years. The assets would be worthless in the end of the project. Operating costs are 36% of sales, and fixed costs of 430 per year. The additional net working capital is negligible. The marginal tax rate of the company is 28%.

   - What is the operating cash flow expected every year from the project?

     From equation 1 we get:

     $$3,000 \times (1-0.36) - 430 - (3,000 \times (1-0.36) - 430 - 4,500/5) \times 0.28 - 0 = 1,324.80$$

   - Using a 10.6% discount rate, calculate the project's NPV

     The investment cash flow is -4,500 (investment in the assets), and the divestment cash flow is zero: the assets are fully depreciated and worthless in the end of the project. We get:

     $$-4,500 + 1,324.8 \times \frac{(1 - 1.106)^{-5}}{0.106} = 445.99$$

   - What is the NPV break-even cash flow of the project?

     It is the cash flow that would provide a zero NPV:

     $$4,500 \times \frac{0.106}{\left(1 - 1.106^{-5}\right)} = 1,205.34$$

   - Which amount of sales would be necessary to get the NPV break-even cash flow?

     From the operating cash flow calculation, and the result of the NPV break-even cash flow above, we have:

     $$\text{Sales} \times (1-0.36) - 430 - \left(\text{Sales} \times (1-0.36) - 430 - 4,500/5\right) \times 0.28 - 0 = 1,205.34$$

     Thus
     $$\text{Sales} = \frac{\left(1,205.34 + 430 - \left(430 + 4,500/5\right) \times 0.28\right)}{(1 - 0.36) \times (1 - 0.28)} = 2,740.75$$

2. Table 8 shows the EBITDA forecasts for an investment project. The investment in fixed assets would be 3,400 depreciated to zero over 4 years. It is estimated that the assets might be sold for 420 in the end of the project. The net working capital would amount to 8% of the EBITDA and the tax rate is 1/3. Assume that the required discount rate is 9.4%. What is the NPV of this project? Its profitability index?

   Table 9 details the calculation of the total cash flow for every year. The NPV is then given by:

   $$-3,465.60 + \frac{767.60}{1.094} + \frac{1,302.80}{1.094^2} + \frac{1,750.00}{1.094^3} + \frac{1,782.00}{1.094^4} + \frac{1,624.00}{1.094^5} = 1,940.85$$

   The profitability index is then:
   $$1 + \frac{1,940.85}{3,465.60} = 1.56$$

3. A company has to replace a float of delivery vehicles and is considering two options:

   - buying the vehicles. The total price would be 200,000, the servicing would cost 15,000 per year, the vehicles would be depreciated straight line to zero over 3 years. They would actually be worthless and have to be replaced every three years.
   - renting the vehicles. The cost would be 80,000 per year, servicing included.

   You might assume that both options are renewable without any change in the future. All costs are before tax, the marginal tax rate is 30% and the required rate of return 11%. Which option has the lowest annual cost?

   Table 10 details the calculation of the equivalent annual costs.

Year	0	1	2	3	4	5
Investment	-3,400					
EBITDA		820	1,600	2,200	2,200	1,800
Depreciation		850	850	850	850	
EBT		-30	750	1,350	1,350	1,800
Taxes @1/3		-10	250	450	450	600
NWC		66	128	176	176	144
NWC Increase	66	62	48	0	-32	-144
Operating cash flows	-66	768	1,302	1,750	1,782	1,344
Divestment cash flow						280
Total cash flows	-3,466	768	1,302	1,750	1,782	1,624

Table 9: Exercise 2 cash flows

Option	Buying	Renting
Investment	-180,000	
EBITDA	-15,000	-80,000
Depreciation	60,000	0
EBT	-75,000	-80,000
Taxes @30%	-22,500	-24,000
Operating cash flow	7,500	-56,000
NPV	-161,672	
Equivalent annual cost	-66,158	-56,000

Table 10: Exercise 3 calculation