Chapter 11 | overview

This chapter deals with the economics of a project. It reveals how the financial justification of a project can be calculated and demonstrated. A number of economic project parameters are introduced and defined. Time value of money is introduced. Categories of projects and their desired profitability are presented. The calculation of the economic parameters is based on the capital outlay and the project proceeds over the years. Cash Flow and Operating Income are elements of these proceeds.

The chapter details what input is needed for calculating the parameters and where to find or how to define these inputs. Three projects, different in nature as to level and timing of the proceeds are compared. It is demonstrated how the differences impact the defined economic parameters. Finally the rationale behind applying a multiple of parameters is underpinned.

Chapter 11 | outline

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Chapter 11

Economic project evaluation

by Jan Wagenmakers

11.1 | Introduction

This chapter deals with the economics of a project. The outcome of the economic project evaluation depicts the financial viability of a project.

In its project selection process the owner will consider a number of aspects such as company strategy, production technology, marketing, personnel and importantly also the financial aspects. The results of the economic evaluation are important to the management (representing the owner), which takes the go-no-go decision on the execution of a project. As the decision is quite often a choice between a number of project opportunities, a profitable prospect provided by the economic project evaluation is a major decision criterion.
In contrast to some other aspects of managing a project the economic project evaluation is based on an arithmetic model. This model itself is not subject to strategy, tactics or approaches. The input for the model – the financial data – however is influenced by the business management view and as a result strategy, tactics and approaches do affect the outcome of the economic project evaluation.
Nonetheless models do not take decisions, people do. So the evaluation outcome is only a part of the decision process; an important one however.
Economic evaluations take place at the various stages of a project. The data are provided by the business case; both capital investment estimates and financial yield of the project under consideration. As the business case is reviewed at various stages of the project the data used in the project evaluation firm up and the outcome increases in reliability.

During the period that I served at the Delft University of Technology, I supervised student teams working on conceptual design projects in their pre- and postmaster programmes. The subjects concerned Chemical and Biochemical Engineering. At the end of the project the results were presented to the staff and supervisors.
By using the following comments I tried to box the mindset of these teams for the task.

'In a number of years from now many of you will be members of a project team in the process industry. You will have to present your results to an approval or appropriation committee. When that day comes – having done your utmost – you will leave the board room and see that another project team is waiting to sell their project to the same committee. This committee only has a certain budget to invest and not all the appropriation proposals can be granted. Make sure your project is selected. So now, as a student, prepare your presentation in a way as if it were to be given to the committee of the company that assigned the project to you.'

The economic evaluation can be performed in a number of ways using various indicators. The level of these indicators for the project at hand define the financial attractiveness of the project. Each indicator has its own meaning about the company, the decision makers and the project perspective.
Those stated below are the common ones:

- Payback period (PBP)
- Internal (or Investor's) rate of return (IRR)
- (Net) Present Value ((N)PV)
- Return on investment (ROI)

These indicators are defined in detail in the next paragraphs.

11.2 | Definition of the economic parameters

Payback period (PBP):
Payback Period (Seider et al., 2009) is the time required for the annual earnings (Cash Flow, Net Income + Depreciation, see 11.5) of the plant operation – the plant being the result of the project – to equal the original investment. As a rule here the Total Depreciable Capital (TDC) is used. For definitions of TDC and TIC: see Paragraph 11.5. The following equation represents this:

$$TDC = \sum_{n=1}^{10} (CF)_n$$

In this equation **n** is the PBP in years. As the annual earnings may not be constant over the years, particularly in the early years of the operation, it is not fully accurate to state: PBP (years) = TDC/(annual) CF.

Return on investment (ROI):
The Return on Investment is the ratio between the Operating Income (OI, defined in Paragraph 11.5) and the Total Invested Capital (TIC) (www.dsm.com, www.akzonobel.com).

$$ROI = \frac{\text{Operating Income}}{\text{Total Invested Capital}} = \frac{OI}{TIC}$$

The ROI is expressed as an annual percentage number when in the formula the annual OI is filled in. This ROI number may fluctuate from year to year in the plant operation as OI may fluctuate. Another way to express the ROI is by calculating it over the estimated life of the plant operation. For definition of estimated life of the plant operation, see Paragraph 11.5. In that case the average OI (total OI divided by the estimated life of the plant operation n in years) is incorporated in the formula:

$$ROI = \left(\sum_{n=1}^{10} (OI)_n * \frac{100}{n}\right) / TIC$$

Usually the value in the denominator (TIC) is kept constant over the years. The alternative is that the average asset value – asset value averaged over the estimated life of the plant operation – is applied in the denominator.
In contrast to PBP and ROI, indicators such as PV, NPV and IRR include time value of money.

Present value (PV):
The Present Value is the value of the future (or projected) Cash Flow from the plant operation in value of money of today (current buying power).

$$PV = \sum_{n=1}^{10} (CF)_n / (1 + r)^n \qquad \text{where } r = \text{discount rate.}$$

The summation starts with n=1 being the first year of the plant operation and ends with n=10, being the end of the estimated life of the plant operation. The discount rate r is applied at the end of the year.

Net Present Value (NPV):
The Net Present Value has much similarity with PV. However, NPV covers a longer period: the investing period as well as the operational period right throughout to the end of the estimated life of the plant operation. So it is the value of the (negative) Cash Flows (CFs) in the investing period plus the projected CFs from the operation in value of money today.

$$NPV = \sum_{n=0}^{10} (CF)_n / (1 + r)^n \qquad \text{where } r = \text{discount rate.}$$

n=0 in the final year of the investing period and negative in the years before that. In the formula above, for simplicity reasons, the TIC is incorporated in year n=0.

Internal rate of return (IRR):
The Internal Rate of Return is the discount rate r in the formula of the NPV under the condition that the NPV is zero. The formula for calculating the IRR for an estimated life of the plant operation of 10 years is:

$$IRR = r \ @ \ NPV = \sum_{n=0}^{10} (CF)_n / (1 + r)^n = 0$$

Here the investment is taken in year n=0 and r is calculated by iteration.

11.3 | Time value of money

11.3.1 Introduction

The value of money is time-related. It is assumed that money in the bank has a higher absolute value in the future than the nominal amount of today; the reason being the interest paid by the bank.

Therefore, in the case of an interest rate > 0 the future nominal value of money will be higher than the nominal value per today. When at the end of year 0 €100 is put in the bank, the nominal value of this €100 at the end of year n will develop as the numbers in Table 11.1 depict.

Table 11.1: Future nominal money value

	Interest rate			
Year	2 %	4 %	8 %	10 %
0	100	100	100	100
1	102	104	108	110
2	104	108	117	121
3	106	112	126	133
4	108	117	136	146
5	110	122	147	161

The nominal value at the end of year n equals:

$$\text{Amount } (€100) * (1+ i)^n$$

where i = interest rate.

The opposite is also true: money kept in a safety deposit box will lose value over time as a result of inflation. The nominal value remains the same but the buying power diminishes. Table 11.2 demonstrates how the buying power of €100 (nominal at the end of year 0) develops over the subsequent 5 years at different inflation rates. The numbers express the buying power at the end of each year.

Table 11.2: Loss of money buying power over the years

	Inflation rate			
Year	2 %	4 %	6 %	10 %
0	100	100	100	100
1	98	96	94	91
2	96	92	89	83
3	94	89	84	75
4	92	85	79	68
5	91	82	75	62

The buying power of the money at the end of year n equals:

$$\text{Amount } (€\,100) / (1 + t)^n$$

where t = inflation rate

The outcome of the formula **$1/(1+t)^n$** is referred to as **Inflation factor** in year n.

11.3.2 Time value of money in economic project evaluation

As depicted in Table 11.2, in current buying power, € 100 to be earned 5 years from now is worth less than € 100 to be earned next year.

In the economic project evaluation this aspect is taken into consideration. The projected earnings (the annual Cash Flows) of the operation are discounted against a defined discount rate. This method is called **Discounted Cash Flow (DCF) Calculation**.
Time value of money is reflected in (Net) Present Value and IRR calculations.

For the discount rate different inputs can be considered

- Inflation %: For a project evaluation this is too mild as it only considers the loss in buying power.
- Interest %: This is more realistic as the number now represents the percentage of the money to be made by depositing money in the bank (own capital) or to be paid to the bank in case of a loan.
- Instead of interest rate the more comprehensive term WACC (Weighted Average Cost of Capital) can be considered. This represents the average on all of a company's securities such as stocks, bonds and other debts. The resulting rate is what the firm would use as a minimum for evaluating a capital project or investment (WACC, 2014).

Table 11.3: Present Value calculations Project I

	Cash Flow	DCF against			
Year	k€	4 %	9 %	14 %	
1	100	96	92	88	
2	120	111	101	92	
3	150	133	116	101	
4	200	171	142	118	
5	250	205	162	130	
6	300	237	179	137	
7	300	228	164	120	
8	300	219	151	105	
9	200	141	92	62	
10	250	169	106	67	
	2170				CCF
		1711	1304	1020	CDCF

DCF = Discounted Cash Flow
CCF = Cumulative Cash Flow
CDCF = Cumulative Discounted Cash Flow = Present Value (PV)

- For the process industry a historic WACC rate of 10 % may apply but more recently 8 % is realistic (Cost of Capital Study, 2012).
- WACC and risk provision %: In the above the aspect '**risk**' is still not fully incorporated. Companies like to see reflected in the discount rate the risk they take in executing the project. So on top of the WACC a percentage is added reflecting the risk taken. This brings the required IRR hurdle to 14 - 18 %.
- In many cases an even more rigorous condition is applied: e.g. the percentage that can be made with an alternative, attractive project.

In Table 11.3 an example is given of the result of applying different discount rates to the predicted Cash Flows of a project, called Project I.

In this example the Cumulative Discounted Cash Flow (CDCF or PV) @ 14 % in the 10 years of the estimated life of the plant operation yields less than 50 % of the Cumulative Cash Flow (CCF): € 1.02 million versus 2.17 million or 47 %. With a milder discount rate of 4 % the CDCF ends up higher and the ratio CDCF/CCF becomes 79 %: 1.71 / 2.17.

Below the effect and benefit of high Cash Flow in the early years of the project is demonstrated.

Over the estimated life of the plant operation a project II yields the same cumulative Cash Flow (€ 2.17 million) as Project I. However, the cash is generated earlier which is favorable for the Discounted Cash Flow. The higher Cash Flows in these early years are discounted against a lower discount factor as they come in after a smaller number of years and contribute with more DCF. As a result the cumulative Discounted Cash Flow is higher than in the case of Project I.

Table 11.4 shows the data for Project II; the cumulative Cash Flow is the same as for Project I but the cumulative Discounted Cash Flow in Project II is higher for reason as stated above.
For easy reference: compare the numbers of year 6 in Table 11.3 with those in the years 2 and 4 in Table 11.4.

Table 11.4: Present Value calculation for Project II: high Cash Flows in the early years

	Cash Flow	DCF against			
Year	k€	4 %	9 %	14 %	
1	100	96	92	88	
2	300	277	253	231	
3	500	444	386	337	
4	300	256	213	178	
5	250	205	162	130	
6	200	158	119	91	
7	150	114	82	60	
8	130	95	65	46	
9	110	77	51	34	
10	130	88	55	35	
	2170				CCF
		1812	1477	1229	CDCF

Therefore, for comparable projects, those with high Cash Flow in the early years are financially more attractive than those with moderate early Cash Flow.

11.4 | Project types and their desired profitability

11.4.1 Process Industry

Management teams in the industry, tasked with the appraisal of project proposals, will be offered a range of projects. Viewed from a business perspective a number of categories can be defined:

- Strategic projects:
  These projects are to be executed in order to support and bolster the company's (new) strategy. For example: they are conditional to
  - Increase market share or
  - Enter new markets or
  - Enlarge the product portfolio

Although these projects may carry a higher risk than a debottlenecking project, they may be approved with a less attractive financial picture – PBP over 4 years and IRR below 14 % because they serve the (mid- to long term) strategy.

- Safety projects:
  Safety projects serve to enhance the safety of production conditions. Execution is based on other considerations than profitability. In order to come up with economic attractiveness the potential savings of prohibiting accident cost can be taken into account in the profitability calculation.

- Right to operate projects
  Right to operate projects have to be executed to stay within the limits of permits granted. They are also referred to as 'must' projects. Although executing these projects may be regarded as 'spending money with no revenues as a result' there is a bottom line profitability because discontinuing the operation concerned often has a much higher financial impact.

- Other projects:
  Enterprises have their own minimum levels for appraising projects. An IRR level of 14 to 18 % is common in the chemical industry at a PBP not over 3.5 years. But again exceptions exist.
  Notable ones are:
  - High risk projects:
    Projects introducing new technology (new for the company) or aiming at new markets will have a high risk for success. These projects require a short PBP in order not to be exposed to the high risk for a longer time. Exceptions are those projects marked as 'Strategic'.

  - Expansion and debottlenecking projects:
    These projects have comparatively low risk. Moreover they often benefit from low fixed cost as many provisions are already in place and shared with the existing operation. That is the reason why they show (and should show) at least a very short PBP and a high IRR.

One may argue that safety projects do not yield money, but preventing accidents and prohibiting their consequences (including avoiding losses due to repair and claims following accidents and permit infringements respectively) do ensure money.

Where Derek Bok stated:
If you think education is expensive, try ignorance for a while

We can paraphrase him by
If you think safety measures are expensive, try neglect for a while.

11.4.2 Non-Profit Organisations

Management Teams of non-profit organisations like housing corporations may have a different view on project economics. The goal of housing corporations is to provide housing facilities for a reasonable price, whilst minimising financial risks. The money to be invested will be provided by the bank. The financial focus for their house building projects will be on the Income Statement. After having paid the annuity (interest plus repayment) and operating cost the Income Statement should show a slightly positive result to cover the financial consequences of uncertainties. It is worthwhile mentioning that these projects often have a very long projected lifetime of the project result – a house in this case – (and a much lower risk profile). For example, the PBP and the running time of the mortgage may be 30 years or longer.

Capital investments made by the government (central and local government) in most cases will not primarily be based on economic attractiveness within a more limited period (of several years). Many of them also have a very long projected life of the result of the project. Here the focus will be on public purpose, necessity and availability of the required funds. Savings (like cost of pollution), entrance fees (museums, theaters), tax income and touristic promotion of the city involved can be marked as Revenues. But in many cases these projects themselves will never break even. They will be judged on their importance for society as a whole. On a local level they compete with each other to obtain the required funds from the (remainder of) the municipality's annual budget.

In most cases, major infrastructural projects are executed by the government. The operation activity (e.g. operating a railroad connection) may be given in concession to private or semi-private parties. The latter consider the economic attractiveness as important. Often they will be limited in collecting sufficient revenues as a consequence of the public opinion regarding the price of tickets. This in return determines the price of the concession. In the worst case scenario a subsidy may be required. In a broader picture: subsidies are important drivers for capital investments in developing countries, environmental projects, governmental stimulation and the like.

11.5 | Input for the evaluation model

The economic project evaluation model requires a set of data. Some come in by definition – like the estimated life of the plant operation – but most are delivered by estimating the capital investment level and the profit that can be made with the result of the project.

Estimated life of the plant operation

In calculating the financial attractiveness of an engineering project for manufacturing, the production is given a theoretical number of years.

The physical life of an asset is the period over which the asset is expected to be usable, with normal repairs and maintenance, for the purpose it is acquired. But this is only one component of the estimated life of the plant operation. Also economics – in which are reflected raw materials, end product prices and product substitution – play a role in assessing the estimated life.

For projects concerning manufacturing of hardware applied in mass communication a projected life of the plant operation not over 5 years may be realistic as after that the product may become obsolete. In the chemical industry for many cases 10 years is chosen as an estimated life. For some, more traditional projects 15 years are taken as an input.

Although the real production period (physical life) may be longer – oil and gas assets are normally designed to operate for 25 to 30 years – a very high number of years as an estimated life of the plant operation hardly makes sense in the economic evaluation. The reason is that the additional DCF the asset is assumed to yield becomes marginal after 10 years when a realistic discount percentage (like for instance 16 %) is applied.

Capital Investment

As stated above, the Present Value of a project represents the amount of money in value of today that the project is expected to yield with the plant operation. The picture becomes more realistic when this number includes the capital cost required to realise the project. The number is then called the Net Present Value, NPV. Calculating the Internal Rate of Return (IRR) is based on the NPV so the capital investment level is incorporated.

In calculating the IRR the Total Invested Capital (TIC) is used. This is the one-time expense for the design, construction and start-up of a new plant.

The Pay Back Period (PBP) is calculated on the basis of the Total Depreciable Capital (TDC) which is defined as the TIC minus Value of Land minus Start-up Cost minus Working Capital.

Cash Flow, Net Profit

To arrive at these data an Income Statement (or Profit & Loss Statement) is to be made, for every year of the operation. The Income Statement is the financial statement showing the profit (or loss) earned by a business over an accounting period (as a rule one year). The Income Statement depicts the Cash Flow, Operating Income and Net Income.

Income Statement

A somewhat simplified Income Statement for a project is given in Table 11.5, indicating which data are used in calculating IRR, PV, NPV, PBP and ROI. The Business Representative responsible for Marketing and Strategy is to provide data for Revenues. Fixed and Variable Cost is inputted by Project Engineering and Purchasing.

Table 11.5: Example of a Project Income Statement

Project A, year 2	
	M €
Revenues	20
Variable Manufacturing Cost ▸ Raw Materials ▸ Auxiliary Materials (incl. catalysts, solvents) ▸ Quality Control	8
Contribution Margin	12
Fixed Manufacturing Cost ▸ Labor ▸ Utilities/waste treatment ▸ Maintenance ▸ Site Overhead ▸ Insurance premium / tax ▸ Royalties ▸ Depreciation	8.5
Gross Profit	3.5
MAR Cost ▸ Marketing ▸ Administration ▸ R&D	1.2
Operating Income (OI) [1]	2.3
Interest	n/a
Tax	n/a
Net Profit/Net Income (NI)	2.3
Depreciation	1.7
Cash Flow [2]	4

1 Used in calculating ROI
2 Used in calculating IRR, PV, NPV and PBP

Some remarks regarding Table 11.5 are worth mentioning:

- Cash Flow: Cash Flow is the difference between revenues and cost *actually paid*. As depreciation is incorporated in calculating the Net Income and depreciation is not an item actually paid, the depreciation is added to the Net Income to arrive at the Cash Flow.
- Interest: this is a cost item in stating the Income Statement of the project. In larger companies, projects are regarded as *internally funded*. In the economic evaluation the company likes to know what money can be made with the funds provided for the project. So here Interest is not viewed as a project expense and is left out in calculating Net Income. Smaller enterprises must borrow money from the bank and do not always have competing projects. As the interest for this loan is a real cost item (to be paid to the bank) these leveraged or *externally funded* projects incorporate Interest in the Net Income and economic evaluation calculation.
- Tax: to some extent this could be treated like Interest. Some companies disregard Tax in the economic evaluation as the profit is reconciled with the profit of other operations. For them Tax plays a role in the site selection process. In particular smaller companies incorporate Tax here.

In the Income Statements for the examples below (Projects A, B and C) Interest and Tax are not taken into account.

11.6 | Calculating the economic parameters

In this paragraph an example is given of how to calculate the economic parameters discussed above.

A project A with a capital outlay (or TIC) of € 20 million is considered. For simplicity, it is assumed that the total capital investment is spent in one year. Value of Land, Start-up expenses and Working Capital are estimated at a level of € 3 million, which brings the TDC to € 17 million.

Estimated life of the plant operation is set at 10 years. In the final year the Salvage, Land value and the returned Working Capital are estimated to be (nominally) € 1.5 million. This explains the relatively high CF in year 10. Depreciation, linear in 10 years, is at a rate of € 1.7 million per year.

Table 11.6 depicts the projected CFs, Depreciation, Net Income (NI), Operating Income (OI), PV, NPV and IRR for this project. OI and NI are equal (Interest, Tax disregarded) so only NI is stated. For NI and CF the numbers for year 2 are taken from Table 11.5. For the other years the numbers for these 2 items are projections, used as an example.

Depreciation equals TDC divided by estimated life (10 yrs): € 17/10 = € 1.7 million per year. Interest and Tax expenses are PM.

Now return to Table 11.6
The estimated Net Income (NI) is taken from the Income Statement.
Cash Flow equals: Net Income + Depreciation.

ROI is arrived at by dividing OI by TIC. In this case NI divided by TIC as OI equals NI.

The **PV** is calculated at a 10 % discount rate based on the WACC rate and some coverage for risk. The 10 **DCF** terms are: $CF/(1+r)^n$ where n is the year of operation from the first column and r is 10 %.

The **NPV** is calculated similarly to PV but now the terms include year zero, the investing year – that is the year that the project is under construction. NPV equals PV minus TIC when PV and NPV are discounted against the same discount rate.

Note that in Tables 6,7 and 8 for the PV calculation a 10 % discount rate is applied whereas in the NPV calculation the IRR is applied, bringing the NPV to 0.

The **IRR** (17 %) is obtained by iteration: iterate the r in the formula of NPV ($\Sigma(CF)n/(1+r)^n$) to a level that the sum of the 11 terms (n runs from 0 to 10) equals zero. (Goal seek in Excel)

The **PBP** is calculated by deducting the CF in the early years from the TDC (€ 17 million) until the remainder is zero. In this example the PBP is 4 years.

Table 11.6: Calculating Economic Parameters

	Project A	
TIC	20	M €
TDC	17	M €
Estimated life	10	years
Depreciation	1.7	M €

Year	Net Income	Depreciation	Cash Flow	DCF @	DCF @	ROI
	M€	M€	M€	10 %	17.0 %	%
0			-20		-20	
1	1.3	1.7	3	2.7	2.6	6.5
2	2.3	1.7	4	3.3	2.9	11.5
3	3.3	1.7	5	3.8	3.1	16.5
4	3.3	1.7	5	3.4	2.7	16.5
5	3.3	1.7	5	3.1	2.3	16.5
6	2.8	1.7	4.5	2.5	1.8	14
7	2.8	1.7	4.5	2.3	1.5	14
8	2.3	1.7	4	1.9	1.1	11.5
9	2.3	1.7	4	1.7	1.0	11.5
10	3.3	1.7	5	1.9	1.0	16.5
	27	17	24	26.6	0.0	13.5
			CCF	PV	NPV	avg. ROI
			PBP = 4 yrs		IRR = 17 %	

Note: Operating Income = Net Income as Interest and Tax are disregarded

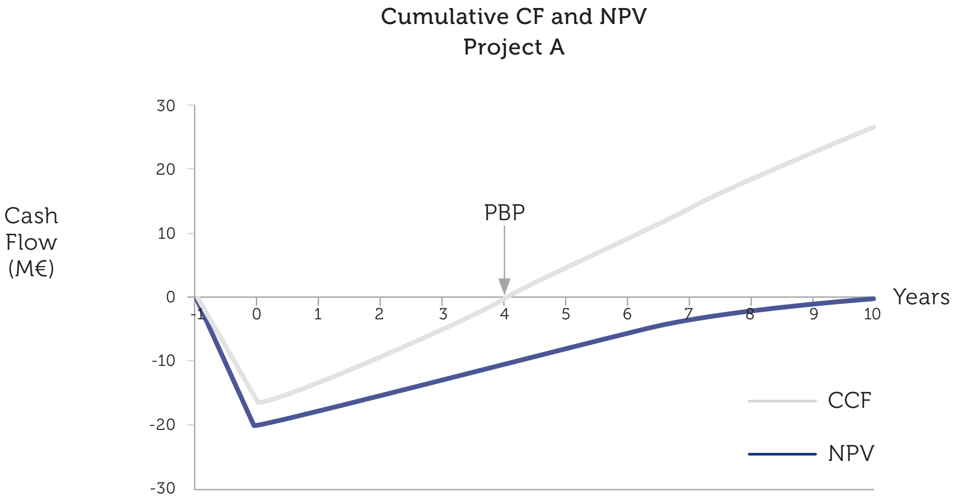

Figure 11.1: Development of Cash Flow and Net Present Value, discounted against the IRR

In Figure 11.1 the CCF, starting at the TDC level of – €17 million is given. The curve of the CCF intercepts the x-axis at year 4, being the PBP. Also the NPV, discounted against the IRR (17.%) and starting at – €20 million (the TIC) is given. At the end of the estimated plant production period, the NPV is 0 when as a discount the IRR is applied.

11.7 | Economic and sensitivity analysis

Estimated life of the operation and discount rate are well defined for a given project. All data are provided by the business case, depicting the various estimates. Numbers for TIC and TDC estimates are provided by the project cost estimating process. With the feasibility study being complete, the accuracy level can be as good as ± 10 %.

The other sets of numbers – those for Cash Flow and Operating/Net Income – used in calculating the economic parameters are provided by the projected annual Income Statements. As a result, CF and OI/NI are projections over a longer time. Their accuracy is impacted by many aspects including:

- raw material and energy price development
- final product price development being a result of:
  - actions of competitors
  - potential product substitution
  - social acceptance of the product over time
- sustainability of patent protection.

With this in mind it is understood that the economic attractiveness of a given project depends heavily on the CF and OI/NI to be generated, keeping in mind that these input items have a low level of accuracy.

In order to address this **risk** element a sensitivity analysis is performed.

For the Base Case Scenario, PBP, ROI, (N)PV and IRR are calculated using the best estimated numbers for TIC, TDC, CF and OI/NI. In the best and worst case scenario signifying lower numbers (pessimistic) and higher numbers (optimistic) respectively are inputted for those aspects having a high impact.

Below is an example how this can be applied:

	best estimate	pessimistic	optimistic
TIC, TDC:	'100'	130 %	90 %
Raw materials price:	'100'	150 %	70 %
Final product price:	'100'	75 %	115 %

So for the worst case (pessimistic) a 30 % overrun on cost is anticipated.

A carefully chosen combination of the numbers above – used as an input – will represent the best and worst case respectively. It is not likely that all choices will result in either poor or excellent outcomes because, for example, raw materials and final product prices may change dependently in the same direction.

As stated above, CF is a very important element with a strong impact on the economic parameters. Both the sum of the CFs over the years (CCF) and the spread over the years are important.

Below a pair-wise comparison is made between 3 projects.

For the process industry 3 projects (A, B and C) are envisaged. All 3 have a Total Depreciable Capital of € 17 million. Also the Total Invested Capital is the same for all three: € 20 million
Project A will deliver a product which needs a market initiation period. As a result, the CFs in year 1 through 3 are modest.
Project B will lead to the production of a product that will gain market share and will show reasonably good sales early on. Therefore the CFs in the years 1 through 3 are high. But after that some product substitution may set in.
The production processes of **Project A and B** are not protected by a patent. During the estimated lifetime **Project A and B** will yield the same CCF: € 24 million.
The product, being the result of **Project C**, is completely new which leads to a market introduction with limited early success and consequently moderate sales volumes in the early years. CFs are identical to those of Project A. But the process and the product are protected by patents. As a result the CFs are good until year 8. The CCF is high: € 31 million.
Below it is stipulated how these different conditions impact the economic parameters.

The development of the Operating Cash Flows (CFs excluding the TIC) of the 3 projects are given in Figure 11.2

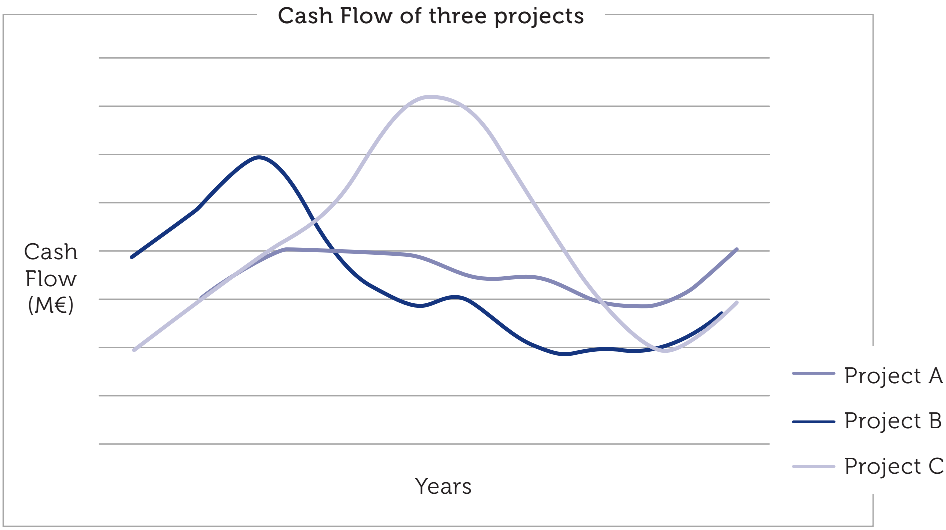

Figure 11.2: Comparing the Operating Cash Flows for three projects

Effect of high CFs in the early years: compare Project B with Project A
The data resulting from Project A have been given in Table 11.6.
The product of Project B has a good start. It is successful in the market leading to high CFs in year 1 through 3. Project B is a frontloaded CF project. After year 3 the CFs are tapering off. Compared with Project A, high CFs (year 1 - 3) are discounted against a lower factor as they come in early (for easy reference: see also Paragraph 11.3.2).

In Table 11.7 the data for Project B are given. The effect of the more attractive CF distribution (more CF in early years) has its effect on PBP, which drops by 1.1 year (from 4 to 2.9 years), a significant period of time.
The IRR increases from 17 % to 20.9 %, which is quite a step as well.
The PV goes up from € 26.6 million to € 28.7 million.
The ROI (13.5 %) is not affected as the cumulative NI stays unchanged at € 24 million. The annual ROI for Project B (Table 11.7) is more attractive in the early years though.

Effect of higher CFs in the later years: comparing Project C with Project A
One should understand that when the cumulative CF goes up, most of the parameters benefit and look more attractive.
This is demonstrated in Table 11.8, representing the data from Project C. The cumulative CF is € 31 million: € 7 million more than that of Project A. In both projects the CF in the operating years 1 to 3 is the same however. During the years 4 to 7 Project C yields higher CFs.

The effect is as follows (comparing data of Project C with those of Project A; Table 11.8 with Table 11.6):

Table 11.7: Effects of a front-loaded Cash Flow project on Economic Parameters

	Project B					
Year	Net Income	Depreciation	Cash Flow	DCF @	DCF @	ROI
	M€	M€	M€	10 %	20.9 %	%
0			-20		-20	
1	3.3	1.7	5	4.5	4.1	16.5
2	4.3	1.7	6	5.0	4.1	21.5
3	5.3	1.7	7	5.3	4.0	26.5
4	3.3	1.7	5	3.4	2.3	16.5
5	2.3	1.7	4	2.5	1.6	11.5
6	2.3	1.7	4	2.3	1.3	11.5
7	1.3	1.7	3	1.5	0.8	6.5
8	1.3	1.7	3	1.4	0.7	6.5
9	1.3	1.7	3	1.3	0.5	6.5
10	2.3	1.7	4	1.5	0.6	11.5
	27	17	24	28.7	0.0	13.5
			CCF	PV	NPV	avg. ROI
			PBP = 2.9 yrs		IRR = 20.9 %	

- PV: increases by € 4.5 million
- IRR: goes up from 17 % to 21.1 %
- ROI moves up from 13.5 % to 17 %

The PBP, however, remains almost unchanged: 3.8 and 4 years respectively. This is because the CFs in year 1 through 3 are the same.

This example demonstrates the limitation when taking into account only one parameter. On the basis of PBP the Project B (Table 11.7) looks most attractive, but PBP disregards the higher CFs in subsequent years.

Table 11.8: Effects of high Cash Flows in later years on Economic Parameters

	Project C					
Year	Net Income	Depreciation	Cash Flow	DCF @	DCF @	ROI
	M€	M€	M€	10%	21.1%	%
0			-20		-20	
1	1.3	1.7	3	2.7	2.5	6.5
2	2.3	1.7	4	3.3	2.7	11.5
3	3.3	1.7	5	3.8	2.8	16.5
4	4.3	1.7	6	4.1	2.8	21.5
5	6.3	1.7	8	5.0	3.1	31.5
6	6.3	1.7	8	4.5	2.5	31.5
7	4.3	1.7	6	3.1	1.6	21.5
8	2.3	1.7	4	1.9	0.9	11.5
9	1.3	1.7	3	1.3	0.5	6.5
10	2.3	1.7	4	1.5	0.6	11.5
	34	17	31	31.1	0.0	17
			CCF	PV	NPV	avg. ROI
			PBP = 3.8 yrs		IRR = 21.1%	

11.8 | Significance of the economic parameters

Those who decide on the selection and approval of a project have a long list of considerations playing a role in the approval process. Economic evaluation data is just one of them.

In the above examples, four economic parameters (PBP, (N)PV, IRR, ROI) are discussed. Generally the appropriation committee has a set of company, division or business unit standards against which they check the level of the parameters for the project under discussion.

As discussed above each parameter has a different meaning and stipulates a unique aspect (Burke, 2003; Kapur, 2004; Bhatia, 2014; De Neufville & Stafford, 1969).

PBP is a parameter easy to relate to and often plays a very important role. How long does it take before the invested money is recuperated? How long will the money be exposed to **risks**?

The annual Cash Flows are the basis for calculating the PBP. These CFs however are projections or expectations. During the estimated life of the plant operation many assumptions may change. These potential changes (regarding increasing raw material and energy prices, overestimated product uniqueness, competitors' actions, inadequate patent protection) may not happen or may not have consequences in the early years of the projects. Hence a short PBP reduces many of these risks as competition makes investments over a longer time period and fixed project contracts cover raw materials, energy and, to some extent, final product prices. As a result a short PBP makes a project economically attractive. Often a PBP of no longer than 3 years is required in the chemical industry. High-risk projects may require short PBPs.

Drawbacks for focusing on PBP are:

- does not consider time value of money; however for short-time periods this is not quite relevant;.
- does not consider potential (and potentially high) CFs in the period after PBP. The data comparison of Projects A (Table 11.6) and Project C (Table 11.8) substantiate this.

ROI depicts the annual return on the invested capital. It is a good measure for what percentage can be made with the money invested compared to other alternatives. In contrast to PBP, ROI is based on the Operating Income, annually provided by the (plant) operation. Depreciation is regarded as a cost.

ROI as a measure is popular because it can easily be used for comparisons with running projects.

For many companies a level of 12 % is minimally desired. It does not take into account the time value of money.

(N)PV and **IRR** are considered as very important as they indicate the money that can be made by operating the project asset, in money of today: in euros and percentage respectively.

In contrast to PBP, (N)PV and IRR view the full period of the project and the projected life of the asset, which is important. When the revenues have a slow start this will affect both PBP and (N)PV-IRR. However the impact on PBP is much more severe. In Paragraph 11.7 examples of these effects are dealt with.

A standard for (N)PV is more difficult to set. It is an amount of money related to the level of capital investment and the discount rate applied. In particular this discount rate will have a relation to prevailing interest rates and risk associated with the project.

IRR is a more encompassing parameter as it incorporates almost everything discussed above:

- time value of money
- capital outlay
- level of CFs and when obtained
- outcome not affected by inflation and interest rate

The level desired for approval reveals the anticipated risk rate. High-risk projects require a high IRR. For projects with a risk level anticipated to be moderate, the desired IRR in the industry is 14 % to 18 %, depending on the company standards.

The three projects from Tables 11.6, 11.7 and 11.8 yield the following values for these parameters:

Table 11.9: Comparing the three projects

Parameter	Unit	Project		
		A	B	C
PBP	yrs	4	2.9	3.8
PV @ 10 %, M€	M€	26.6	28.7	31.1
NPV@ 10 %, M€	M€	6.6	8.7	11.1
IRR, %	%	17	20.9	21.1
ROI, %	%	13.5	13.5	17

For a graphical representation, the PBP, NPV @ 10 %, IRR and ROI of the 3 projects are indicated in Figure 11.3

Despite the higher (N)PV, IRR and ROI of project C, the short PBP of project B makes this project tempting for decision makers, especially those with a focus on the near future.

In conclusion

The economic project evaluation provides valuable information in the selection process of projects. The outcome is based on an arithmetic model. The input data for the calculation model is provided by the capital investment estimates and the projected data in the Income Statements for the various years of the projected lifetime of the operation.
The 4 major parameters (PBP, ROI, (N)PV and IRR) represent different aspects of the evaluation. PBP and ROI do not include time value of money. (N)PV and IRR provide information over the project period and the projected life of the asset. In contrast to PBP they safeguard that profits in later years are duly reflected. However, as the uncertainty of these later years profits in general is high, the accuracy of these two parameters – (N)PV and IRR – has its limitation.

In the project selection and approval process it is recommended to involve multiple parameters.

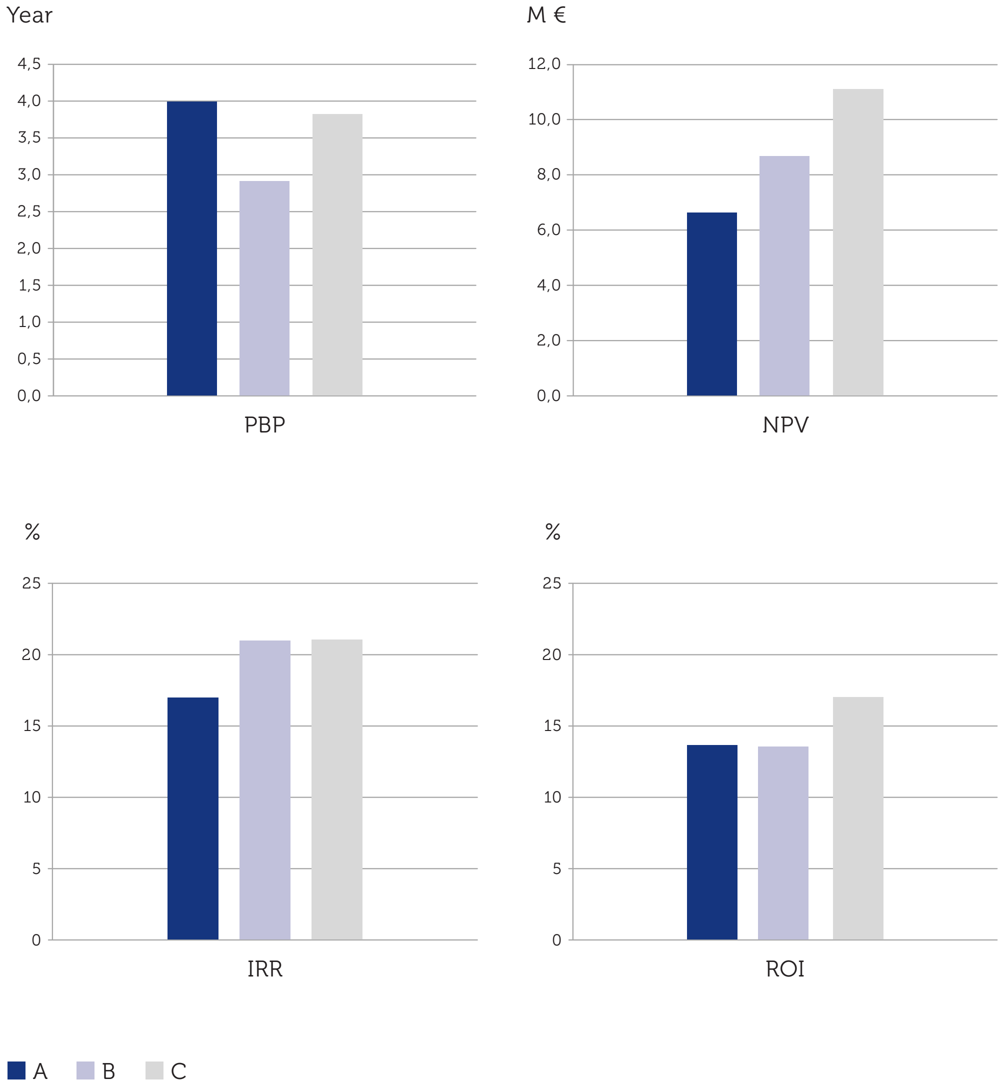

Figure 11.3: Comparing PBP, NPV, IRR and ROI of three projects

It is also recommended that the economic parameters be evaluated not only during the project phase but also after the plant has been producing and the cash has been flowing in for a number of years following the PBP. The responsibility for this rests with the company and is beyond that of the Project Manager.

11.9 | The Wind Farm

The Allwind project case differs from what is considered standard in the process industry. A more moderate IRR is acceptable together with longer PBPs. Nonetheless, projects like WEP oftentimes require subsidies to become economically viable. For the Allwind project the following key economic data are given:

	Base Case (M€)	*Best Case (M€)*
TIC	385	269
TDC	356	246
Revenues from operation	38.5	38.5
Revenues from subsidies	19.2	19.2
Operational cost (maintenance, labour, insurance, etc.)	7.4	5.5
Interest and Tax	n/a	n/a
Depreciation	25.6	17.9
Estimated life of the operation	15 yrs	15 yrs

A simplified Income Statement is given below (numbers in M€)

Case	*Base*		*Best*	
Subsidies	*no*	*yes*	*no*	*yes*
Revenues from Operation	38.5		38.5	
Revenues from Subsidies		19.2		19.2
Total Revenues	38.5	57.7	38.5	57.7
Operational Cost		-7.4		-5.5
Depreciation		-25.6		-17.9
Operating Income (Net Income)	5.4	24.6	15.0	34.2
Cash Flow	31.0	50.3	33.0	52.2

For the above, the economic parameters have been calculated with the following result:

Case	*Base*		*Best*	
Subsidies	*no*	*yes*	*no*	*yes*
PBP (yrs)	11	7	7.5	5
IRR (%)	2	9	8	14
ROI (%)	2	14	6	21

The conclusion is that without subsidies granted to increase the revenues, the project will hardly meet the requirements or not at all. The subsidised best case yields more than acceptable results.