Chapter 20

RISK AND INVESTMENT ANALYSIS

When uncertainty creates value . . .

Valuing an investment by discounting future flows at the weighted average cost of capital can provide some useful parameters for making investment decisions, but it does not adequately reflect the investors' exposure to risk. On its own, this technique does not take into account the many factors of uncertainty arising from industrial investments. Attempting to predict the future is too complicated (if not impossible!) to be done using mathematical criteria alone.

Accordingly, investors have developed a number of risk analysis techniques whose common objective is to *know more about a project* than just the information provided by the NPV. In fact, these techniques allow the investor to:

1. *know* the most important *sources of uncertainty* of a project and the quantitative impact of each of them. With this information, a manager can decide if it is necessary to conduct additional analysis, such as market research, product testing, logistics alternatives, and so on; and
2. *identify* a project's *key value drivers* so that the manager can accurately monitor these factors before, during and after an investment is made.

Nonetheless, these traditional approaches to risk analysis suffer from an important shortcoming: they don't consider *the value of flexibility*. Recently, options theory of investment decisions has begun to allow investors to assess some new concepts that are crucial to investment analysis.

The reader must realise that the business plan is the first stage in assessing the risks related to an investment. The purpose of the business plan is to model the firm's most probable future and it helps to identify the parameters that could significantly impact on a project's value. For example, in certain industries where sales prices are not very important, the model will be based on gross margins, which are more stable than turnover.

Establishing a business plan helps to determine the project's dependence upon factors over which investors have some influence, such as costs and/or sales price. It also outlines those factors that are beyond investors' control, such as raw material prices, exchange rates, etc. Obviously, the more the business plan depends upon exogenous factors, the riskier it becomes.

Section 20.1
A CLOSER LOOK AT RISK

1/ BREAKEVEN ANALYSIS

Managers often want to know what *quantity* of a particular product has to be sold in order to break even or produce a specific profit. Similarly, they may want to know the level of *sales* the new product must reach in order to break even.

The breakeven methodology divides costs into fixed and variable components, and seeks to find the minimum level of output that balances sales with fixed costs. As already discussed (Chapter 10), fixed costs are constant and independent of the quantity produced. It is the variable costs that depend upon production levels.

Suppose a company has an investment opportunity with the following characteristics:

Initial date	JAN 09
Initial investment	€ 2,000,000
Initial sales price per unit (*P*)	€ 60
Annual price change	−2%
Initial cost per unit	€ 40
Annual cost improvement	5%
Interest rate on debt	6%
Project life	5 yrs

The model assumes changing sales volumes and price erosion during the time period. Yet the company can benefit from a decreasing cost per unit over the period. Selling and administration costs also vary each year, but in a way unrelated to sales output. Therefore they are considered as fixed cost.

The model's inputs are:

	Jan-09	Jan-10	Jan-11	Jan-12	Jan-13	Jan-14
Sales volume		50,000	55,000	45,000	35,000	30,000
Price per unit		60	59	58	56	55
Sales revenue		3,000,000	3,234,000	2,593,080	1,976,503	1,660,263
Variable Costs						
Annual cost per unit		40	38	36	34	33
Manufacturing cost		(2,000,000)	(2,090,000)	(1,624,500)	(1,200,325)	(977,408)
Contribution		1,000,000	1,144,000	968,580	776,178	682,855
Fixed costs						
Selling and administration costs		(30,000)	(40,000)	(50,000)	(70,000)	(70,000)
Other		(400,000)	(400,000)	(400,000)	(400,000)	(400,000)
Total fixed costs		(430,000)	(440,000)	(450,000)	(470,000)	(470,000)
Earnings before Interest and tax (EBIT)		570,000	704,000	518,580	306,178	212,855
Interest expenses		120,000	79,800	14,964	–	–

The breakeven formula is:

$$\text{Breakeven } Q = F/(P - V)$$

where: Q is the quantity produced and sold; V is the variable cost per unit; F is the fixed cost; and P the selling price per unit

The revenue breakeven point can be obtained by multiplying:

$$\text{Breakeven } Q \times P$$

In our example, the two breakeven measures are:

Breakeven volume	21,500	21,154	20,907	21,194	20,649	21,081
Breakeven revenues	1,290,000	1,243,846	1,204,739	1,196,834	1,142,736	1,215,631

A better alternative is to calculate the **financial breakeven point**, which includes interest expenses in fixed costs. The breakeven will then become higher:

Financial breakeven volume	27,500	24,990	21,602	21,194	20,649
Financial breakeven revenues	1,650,000	1,469,435	1,244,800	1,196,834	1,142,736

Breakeven analysis is very popular among managers because it gives them very clear targets. In fact, they can specify targets for different areas of the firm (sell 20,000 units, keep variable costs below 50% of the selling price, etc.).

2/ OPERATING AND FINANCIAL LEVERAGE

Operating leverage is the variability of earnings to corresponding changes in revenues. A firm that has high fixed costs relative to total costs will have a high operating leverage, because the cyclicality of operating income will change proportionally more than when sales change.

$$\text{Operating leverage} = \Delta\%\ \text{EBIT}/\Delta\%\ \text{Sales}$$

A firm with a high operating leverage experiences higher variability in EBIT than companies with lower operating leverage. Other things being equal, a higher operating leverage will lead to greater risk for the company (as measured by beta, see Chapter 21).

Although it is difficult for a company to change the incidence of fixed costs, it can follow some strategies that may lead to a lower operating leverage, such as:

- negotiating higher labour flexibility and increasing the percentage of remuneration linked to the financial success of the company;
- creating alliances and joint ventures, with the aim of sharing the fixed costs of new initiatives; or
- subcontracting and outsourcing, which reduce the amount of fixed assets and annual depreciation.

The **unlevered beta**, or **asset beta** (see Chapter 23) and the operating leverage are linked because the unlevered beta is determined by both the business in which the firm operates and the operating leverage of the firm.

Financial leverage is the change in the earnings per share relative to changes in earnings. It is affected by the capital structure policy of the company and thus is highly firm-specific:

$$\text{Financial leverage} = \Delta\%\ \text{EPS}/\Delta\%\ \text{EBIT}$$

Other things being equal, an increase in financial leverage increases the risk (and the beta) of the equity in a firm. Why? Because fixed interest payments on debt will result in high net income in good times and very low net income in bad times.

The **levered (or equity) beta** reflects both the operating and financial risk of a company.

Combined leverage is the product of operating and financial leverage. It is a proxy for the total risk of a company.

Combined leverage = Operating leverage × Financial leverage = Δ% EPS/Δ% Sales

The combined leverage represents an important principle of finance. As it is the product of the financial leverage and the operating leverage, companies should be reluctant to increase the financial leverage if the operating leverage is already high. Conversely, companies with low operating leverage (and therefore operating a stable business) can afford to have a higher debt/equity ratio.

Taking the previous example, if there is additional information that the tax rate is 33% and the number of shares is 10,000, then the three types of leverage are:

	Jan-10	Jan-11	Jan-12	Jan-13	Jan-14
Sales	3,000,000	3,234,000	2,593,080	1,976,503	1,660,263
EBIT	570,000	704,000	518,580	306,178	212,855
Interest	(120,000)	(79,800)	(14,964)	–	–
Earnings before tax	450,000	624,200	503,616	306,178	212,855
Tax	(148,500)	(205,986)	(166,193)	(101,039)	(70,242)
Earnings after tax (EAT)	301,500	418,214	337,423	205,139	142,613
Earnings per share (EPS)	30.15	41.82	33.74	20.51	14.26
Operating leverage					
Change in EBIT		24	(26)	(41)	(30)
Change in sales		8	(20)	(24)	(16)
Operating leverage (DOL)	EBIT/Sales	3.01	1.33	1.72	1.90
Financial leverage					
Change in EPS		39	(19)	(39)	(30)
Change in EBIT		24	(26)	(41)	(30)
Degree of financial leverage (DFL)	EPS/EBIT	1.65	0.73	0.96	1.00
Combined leverage					
Change in EPS		39	(19)	(39)	(30)
Change in sales		8	(20)	(24)	(16)
Degree of combined leverage	EPS/Sales	4.96	0.97	1.65	1.90

3/ SENSITIVITY ANALYSIS

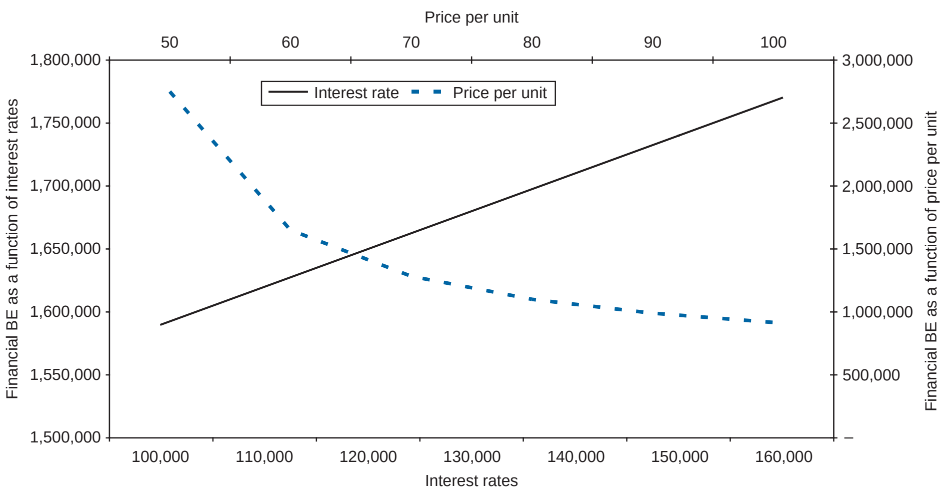
One important risk analysis consists in determining how sensitive the investment is to different economic assumptions. This is done by *holding all other assumptions fixed* and then applying the present value to each different economic assumption. It is a technique that highlights the consequences of changes in *prices*, *volumes*, *rising costs* or *additional investments* on the value of projects.

To perform a sensitivity analysis, the investor:

1 fixes a base-case set of assumptions and calculates the NPV; and
2 allows one variable to change while holding the others constant, and recalculates the NPV based on these assumptions. Usually analysts develop both pessimistic and optimistic forecasts for each assumption, and then analysts move to a more complete range of possible values of the key drivers (see the figure below for an example).

The sensitivity analysis requires a good understanding of the sector of activity and its specific constraints. The industrial analysis must be rounded off with a more financial analysis of the investment's sensitivity to the model's technical parameters, such as the discount rate or terminal value (exit multiple or growth rate to infinity).

SENSITIVITY ANALYSIS OF FINANCIAL BREAKEVEN



Practitioners usually build a sensitivity matrix, which offers an overview of the sensitivity of the investment's NPV to the various assumptions.

4/ SCENARIO ANALYSIS AND MONTE CARLO SIMULATION

With a **scenario analysis**, the analyst calculates the project NPV assuming simultaneously a whole set of new assumptions, rather than adjusting one assumption at a time. For example, the analyst may foresee that if production volume falls short of expectations, operating costs per unit may also be higher than anticipated. In this case, two variables change at the same time. But as the reader can easily understand, in reality the situation may be much more complex.

Although scenario analysis is appealing, it can be very difficult to understand how different variables are related to each other. The problem is two-sided:

- What are the assumptions that move together? and
- What is the strength of their relationships?

As with sensitivity analysis, companies often build a base-case (or concensus) scenario and then move to optimistic and pessimistic scenarios. In our example, the two alternative scenarios lead to the following results:

SCENARIO SUMMARY

	Current values	Best case	Worst case
Volume	50,000	55,000	46,000
Price per unit	60	63	58
Cost per unit	40	38	41
Interest expense	120,000	110,000	130,000
Financial breakeven	**1,650,000**	**1,360,800**	**1,910,588**

An even more elaborate variation of scenario analysis is the **Monte Carlo simulation**, which is based on more sophisticated mathematical tools and software. It consists of isolating a number of the project's key variables or value drivers, such as turnover or margins, and allocating a probability distribution to each. The analyst enters all the assumptions about distributions of possible outcomes into a spreadsheet. The model then randomly samples from a table of predetermined probability distributions in order to identify the probability of each result.

Assigning probabilities to the investment's key variables is done in two stages:

1. First, influential factors are identified for each key variable. For example, with turnover, the analyst would also want to evaluate sales prices, market size, market share, etc.
2. It is then important to look at available information (long-run trends, statistical analysis, etc.) to determine the uncertainty profile of each key variable using the values given by the influential factors.

Generally, there are several types of key variables, such as simple variables (e.g. fixed costs), compound variables (e.g. turnover = market × market share), or variables resulting from more complex, econometric relationships.

The investment's net present value is shown as an uncertainty profile resulting from the probability distribution of the key variables, the random sampling of groups of variables, and the calculation of net present value in this scenario.

Repeating the process many times gives us a clear representation of the NPV risk profile.

Once the uncertainty profile has been created, the question is whether to accept or reject the project. The results of the Monte Carlo method are not as clear cut as present value, and a lot depends upon the risk/reward tradeoff that the investor is willing to accept. One important limitation of the method is the analysis of interdependence of the key variables, for example, how developments in costs are related to those in turnover, etc.

Section 20.2
THE CONTRIBUTION OF REAL OPTIONS

1/ THE LIMITS OF CONVENTIONAL ANALYSIS

Do not be confused by the variety of risk analysis techniques presented in the preceding section. In fact, all of these different techniques are based on the same principle. In the final analysis, simulations, the Monte Carlo or the certainty equivalent methods are just complex variations on the NPV criteria presented in Chapter 16.

Like NPV, conventional investment risk analyses are based on two fundamental assumptions:

- the choice of the anticipated future flow scenario; and
- the irreversible nature of the investment decision.

The second assumption brings up the limits of this type of analysis. Assuming that an investment is irreversible disregards the fact that corporate managers, once they get new information, generally have a number of options. They can abandon the investment halfway through if the project does not work out, they can postpone part of it or extend it if it has good development prospects, or use new technologies. The teams managing or implementing the projects constantly receive new information and can adapt to changing circumstances. In other words, **the conventional approach to investment decisions ignores a key feature of many investment projects, namely flexibility.**

It might be argued that the uncertainty of future flows has already been factored in via the mathematical hope criteria and the discount rate, and therefore this should be enough to assess any opportunities to transform a project. However, it can be demonstrated that this is not necessarily so.

The discount rate and concept of mathematical hope quantify the direct consequences of random events. However, they do not take into account the manager's ability to change strategies in response to these events.

2/ REAL OPTIONS

Industrial managers are not just passively exposed to risks. *In many cases, they are able to react to ongoing events*. They can increase, reduce or postpone their investment, and they exercise this right according to ongoing developments in prospective returns.

In fact, the industrial manager is in the same situation as the financial manager who can increase or decrease his position in a security given predetermined conditions.

Industrial managers who have some leeway in managing an investment project are in the same position as financial managers holding an option.[1]

The flexibility of an investment thus has a value that is not reflected in conventional analysis. **This value is simply that of the attached option.** Obviously, this option does not take the form of the financial security with which you have already become familiar. It has no legal existence. Instead, it relates to industrial assets and is called a **real option**.

1 *If you are not familiar with options, we advise you to read Chapter 28 before reading the rest of this chapter.*

Real options relate to industrial investments. They represent the right, but not the obligation, to *change* an investment project, particularly, when new information on its prospective returns becomes available.

The potential flexibility of an investment, and therefore of the attached real options, is not always easy to identify. Industrial investors frequently do not realise or do not want to admit (especially when using a traditional investment criterion) that they do have some margin for manoeuvre. This is why it is often called a **hidden option**.

3/ REAL OPTIONS CATEGORIES

The theory of real options is complex but, like any conceptual universe, it helps us to discuss and analyse problems.

Given the potential value of hidden options, it is tempting to consider all investment uncertainties as a potential source of value. But the specific features of option contracts must not be overlooked. The following three factors are necessary to ensure that an investment project actually offers real options:

- The project must have a degree of **uncertainty**. The higher the underlying volatility, the greater the value of an option. If the standard deviation of the flows on a project is low, the value of the options will be negligible.
- Investors must be able to get **more information** during the course of the project, and this information must be sufficiently precise to be useful.
- Once the new information has been obtained, it must be possible to change the project **significantly and irrevocably**. If the industrial manager cannot use the additional information to modify the project, he does not really have an option but is simply taking a chance. In addition, the initial investment decision must also have a certain degree of irreversibility. If it can be changed at no cost, then the option has no value. And lastly, since the value of a real option stems from the investor's ability to take action, any increase in **investment flexibility generates value**, since it can give rise to new options or increase the value of existing options.

Real options apply primarily to decisions to invest or divest, but they can appear at any stage of a company's development. As a result, the review in this text of options theory is a broad outline, and the list of the various categories of real options is far from exhaustive.

The option to launch a new project corresponds to a call option on a new business. Its exercise price is the startup investment, a component that is very important in the valuation for many companies. In these cases, they are not valued on their own merits, but according to their ability to generate new investment opportunities, even though the nature and returns are still uncertain.

A good example of this principle is television channels currently using analog broadcasting. Since the business model of digital broadcasting is still uncertain and the corresponding development costs are high, the value of a television channel is partly based on anticipated changes in the market in which the channel operates. But the value also includes an option to develop in the new digital market, which still remains to be defined.

Similarly, R&D departments can be considered to be generators of real options embedded within the company. Any innovation represents the option to launch a new project or product. This is particularly true in the pharmaceutical industry. If the project is not profitable, this does not mean that the discovery has no value. It simply means that the discovery is out of the money. Yet this situation could change with further developments.

The option to develop or extend the business is comparable to the launch of a new project. However, during the initial investment phase decisions have to be made, such as whether to build a large factory to meet potentially strong demand or just a small plant to first test the waters.

A real options solution would be to build a small factory with an option to extend it if necessary. Flexibility is just as important in current operations as when deciding on the overall strategy of a project. Investments should be judged by their ability to offer recurring options throughout their life cycle. Certain power stations, for example, can easily be adapted to run on coal or oil. This flexibility enhances their value, because they can be easily switched to a cheaper source of energy if prices fluctuate. Similarly, some auto plants need only a few adjustments in order to start producing different models.

The option to reduce or contract business is the opposite of the previous example. If the market proves smaller than expected, the investor can decide to cut back on production, thus reducing the corresponding variable costs. Indeed, he can also decide not to carry out part of the initial project, such as building a second plant. The implied sales price of the unrealised portion of the project consists of the savings on additional investments. This option can be described as a put option on a fraction of the project, even if the investment never actually materialises.

The option to postpone a project. The initial investment in the rights of an oil field is minimal in comparison with prospecting and extraction costs. It can thus be quite useful to defer the start of the project, for example until the business environment becomes more propitious (oil prices, operating costs, etc.). To a certain extent, this is similar to holding a well-known but not fully exploited brand.

There is a certain time value in delaying the realisation of a project, since in the meantime better information about the project's income and expenses may become available. This enables a better assessment of the potential for value creation.

Nonetheless, the option to defer the project's start is valid only if the investor is able to secure ownership of the project from the outset. If not, his competitors may take on the project. In other words, the advantage of deferring the investment could be cancelled out by the risk of new market entrants.

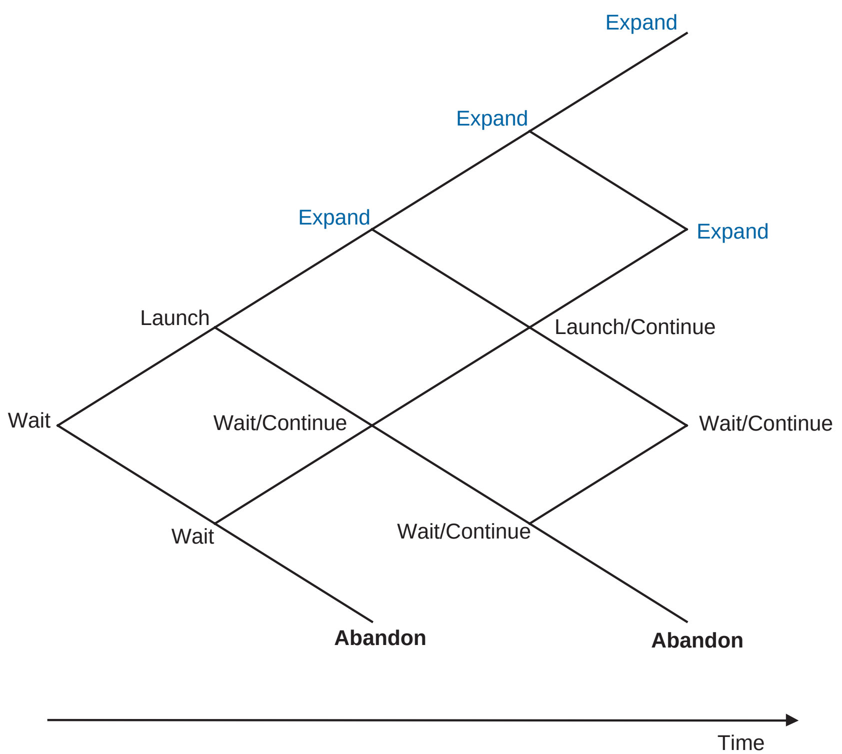
Looking beyond the investment decision itself, **option models can be used to determine the optimal date for starting up a project**. In this case, the waiting period is similar to holding an American option on the project. The option's value corresponds to the price of ensuring future ownership of the project (land, patents, licence, etc.).

The option to defer progress on the project is a continuation of the previous example. Some projects consist of a series of investments rather than just one initial investment. Should investors receive information casting doubt on a project that has already been launched, they may decide to put subsequent investments on hold, thus effectively halting further development. In fact, investors hold an option on the project's further development at every call for more financing.

The option to abandon means that the industrial manager can decide to abandon the project at any time. Thus, hanging on to it today means keeping open the option to abandon at a later date. However, the reverse is not possible. This asymmetry is reflected in options theory, which assumes that a manager can sell his project at any time (but might not be able to buy it back once it is sold).

Such situations are analogous to the options theory of equity valuations that we will examine in Chapter 35. If the project is set up as a levered company, the option to abandon corresponds to shareholders' right to default. The value of this option is equal to that of equity, and it is exercised when the amount of outstanding debt is greater than the value of the project.

In the example below, the project includes an option to defer its launch (wait and see), an option to expand if it proves successful, and an option to abandon it completely.

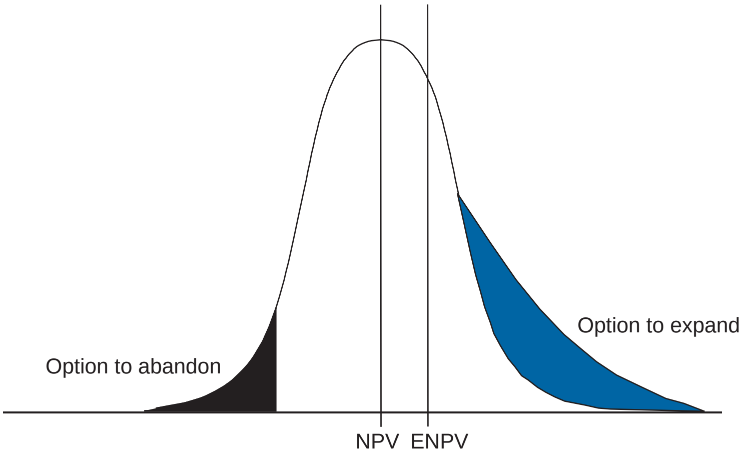


4/ THE EXPANDED NET PRESENT VALUE

Since options allow us to analyse the various risks and opportunities arising from an investment, the project can be assessed as a whole. This is done by taking into account its two components – anticipated flows and real options. Some authors call this the **expanded net present value (ENPV)**, which is the opposite of the "passive" NPV of a project with no options. Based on the preceding sections, this gives:

$$\text{ENPV} = \text{NPV} + \text{Real option value}$$

When a project is very complex with several real options, the various options cannot be valued separately since they are often conditional and interdependent. If the option to abandon the project is exercised, the option to reduce business obviously no longer exists and its value is nil. *As a result, there is no additional value on options that are interdependent*.



5/ EVALUATING REAL OPTIONS

Option theory sheds light on the valuation of real options by stating that uncertainty combined with flexibility adds value to an industrial project. How appealing! It tells us that the higher the underlying volatility, and thus the risk, the greater the value of an option. This appears counterintuitive compared with the net present value approach, but remember that this value is very unstable. The time value of an option decreases as it reaches its exercise date, since the uncertainty declines with the accumulation of information on the environment.

The uncertainty inherent in the flexibility of an industrial project creates value, because the unknown represents risk that has a time value. As time passes, this uncertainty declines as the discounted cash flows are adjusted with new information. The uncertainty is replaced with an intrinsic value that progressively incorporates the ever-changing expectations.

Consider the case of a software publisher who is offered the opportunity to buy a licence to market cell phone software for €50 million. If the publisher does not accept the deal right away, the licence will be offered to a rival. The software can be produced on the spot at a cost of €500 million.

If the software is produced immediately, the company should be able to generate €20 million in cash flows over the next year. The situation the following year, however, is far more uncertain, since one of the main telephone carriers is due to choose a new technological standard. If the standard chosen corresponds to that of the licence offered to our company, it can hope to generate a cash flow of €90 million per year. If another standard is chosen, the cash flows will plunge to €10 million per year. The management of our company estimates there is a 50% chance that the "right" standard will be chosen. As of the second year, the flows are expected to be constant to infinity.

The present value of the immediate launch of the product can easily be estimated with a discount rate of 10%. The anticipated flows are $0.5 \times 90 + 0.5 \times 10 =$ €50 million from the second year on to infinity. Assuming that the first year's flows are disbursed (or received) immediately, the present value is $50/0.1 + 20 =$ €520 million for a total cost of 500 + 50 = €550 million. According to the NPV criteria, the project destroys €30 million in value and the company should reject the licensing offer. This would be a serious mistake!

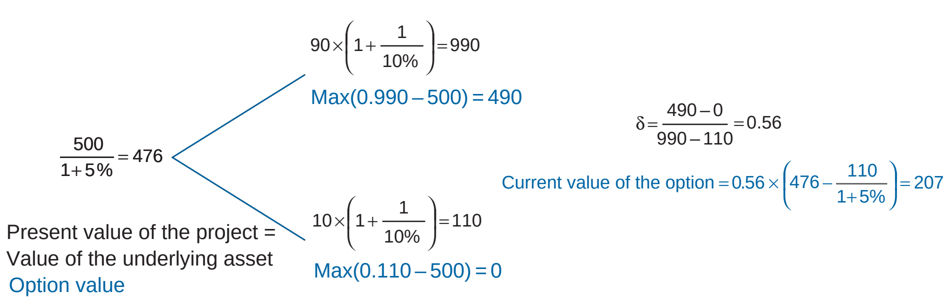
If it buys the licence, the company can decide to produce the software whenever it wants to and can easily wait a year before investing in production. While this means giving up revenues of €20 million the first year, the company will have the advantage of knowing which standard the telephone operator will have chosen. It can thus decide to produce only if the standard is suited to its product. If it is not, the company abandons the project and saves on development costs. The licence offered to the company thus includes a real option: the company is entitled to earn the flows on the project in exchange for investing in production.

The NPV approach assumes that the project will be launched immediately. That corresponds to the immediate exercise of the call option on the underlying instrument. This exercise destroys the time value. To assess the real value of the licence, we have to work out the value of the corresponding real option, i.e. the option of postponing development of the software.

When a company has a real option, using NPV or any other traditional investment criteria implies that it will exercise its option immediately. It is important to keep in mind that this is not necessarily the best solution or the only reality that the company/investor faces.

The value of an option can be determined by the binomial method, which will be described in greater detail in Section 28.5.

Imagine that the company has bought the licence and put off producing the software for a year. It now knows what standard the carrier has chosen. If the standard suits its purposes, it can immediately startup production at an NPV of $90\times(1 + 1/0.1) - 500 =$ €490 million at that date. If the wrong standard is chosen, the NPV of developing the software falls to $10\times(1 + 1/0.1) - 500 = -$€390 million, and the company drops the project (this investment is irreversible and has no hidden options). The value of the real option attached to the licence is thus €490 million for a favourable outcome and 0 for an unfavourable outcome. Using a risk-free discount rate of 5%, the calculation for the initial value of the option is €207 million, since:



Here is another look at the licensing offer. The licence costs €50 million and the value of the real option is €207 million assuming development is postponed one year. With this proviso, the company has been offered the equivalent of an immediate gain of 207 – 50 = €157 million.

In this example, the difference between the two approaches is considerable. Legend has it that when an oil concession was once being auctioned off, one of the bidding companies offered a price that was less than a tenth that of its competitor, quite simply because he had "forgotten" to factor in the real options!

This example assumed just one binomial alternative but, when attempting to quantify the value of real options in an investment, one is faced by a myriad of alternatives. More generally, the binomial model uses the **replicating portfolio approach**: Suppose that we know the value of the option at the end of the period, both in the up- and in the down-state. We could simply obtain the value by discounting the expected value of the two returns at an appropriate discount rate. Although correct, this approach suffers two limitations:

- we do not know the probability of the up and down scenario. This problem can be overcome; and
- the discount rate is not the cost of capital we use in estimating the NPV of the project without flexibility. A real option has different payouts and different risks than the underlying project. Thus the cost of capital inappropriately reflects the riskiness of the cash flows of the project with flexibility.

It is sometimes possible to choose δ shares of a "traded" or twin (of the project with flexibility!) security (an asset named S, which is perfectly correlated with the option) and B euros of risk-free debt. Suppose that if the price goes up, the twin security price will be S_U (supposedly known), while if it goes down will be S_D (also known). In the up-state, the project with flexibility will return P_U (a figure that we are able to estimate as we will see later on) while in the down-state it will return P_D (also estimable). The result is two equations and two unknowns (B and δ):

$$\delta \times S_U + B \times (1 + r_f) = P_U$$

$$\delta \times S_D + B \times (1 + r_f) = P_D$$

The solution of this simple system is:

$$\delta = (P_U - P_D)/(S_U - S_D)$$

$$\mathrm{B} = (P_U - \delta \times S_U)/(1 + r_f)$$

In each node, the present value of the project with flexibility is:

$$\delta \times \text{PV of the project at the node} + \mathrm{B}/(1 + r_f)$$

We then work backward, node by node and in a similar way, to arrive at the present value of the project with real options, i.e. the expanded net present value.

The reader should be aware that the expanded net present value cannot be lower than the "passive" NPV.

But what is this security that is perfectly correlated (the twin!) with a project with real options? The trick is to use the project itself, taking the present value without flexibility, as the twin security. In other words, we use the present value of the "passive" project as an estimate of the price it would have if it were traded on the market. This solution is extremely reasonable and useful because, after all, the project with flexibility has the highest asset correlation with the no-flexibility project.

It is now possible to take all of these tools and create some order out of this line of reasoning. The approach for option valuation is a five-step process. Discussion of the process provides an opportunity to analyse a few other important concepts.

Step 1 **Calculate the "passive" present value of the project**, using the traditional discounted cash flow methods.

Step 2 **Build a so-called event tree**, i.e. the lattice that models the values of the "passive" investment. This tree does not contain decision nodes and simply models the evolution of the present value of the project.

The up and down movements can be determined by the following formulae[2]:

$$\text{Up movement} = U = e^{\sigma\sqrt{T}}$$

$$\text{Down movement} = D = e^{-\sigma\sqrt{T}}$$

The corresponding probabilities of up and down movements are:

$$\text{Probability up} = (1 + r_f - D)/(U - D)$$

$$\text{Probability down} = 1 - \text{Probability up}$$

Step 3 **Turn the event tree into a decision tree**, by identifying the managerial flexibility and building it into the *appropriate* nodes of the tree, i.e. when the flexibility is effectively possible. For example, suppose that it is possible to expand the project and its payouts by 15% by spending an additional €10 at any time. Wherever the exercise of this option is possible in the event tree, multiply by 15%, and reduce by €10 the corresponding node on the original tree. For each node, then choose the maximum value between the original event tree and the tree with the incorporated flexibility.

Step 4 **Use the replication portfolio approach to value the present value of the project with flexibility.** Then the entire decision tree can be solved by working from the final branches backward through time.

$$\delta \times \text{PV of the no-flexibility project at the node} + B/(1 + r_f)$$

Step 5 **Calculate the expanded net present value** by subtracting the initial investment from the present value of the project with flexibility.

2 *If we build the event tree with these up and down movements we are building a geometric tree. The main characteristic is that it has multiplicative up and down movements that model a log-normal distribution of outcomes – whose returns can go to infinity on the up side and to zero on the down side.*

Real options are calculated using quite sophisticated mathematical tools, which iterate the option's flows by a portfolio of financial assets, i.e. the foundation of the binomial method. Estimating volatility is always the most problematic issue regarding the concrete application of this methodology.

In practice, the information derived from the quantification of real options is frequently not very significant when compared with a highly positive NPV in the initial scenario. However, when NPV is negative at the outset, one always has to consider the flexibility of the project by resorting to real options.

In general, Copeland et al. sum up the practice quite succinctly: "For practitioners to use the option pricing approach, it must be relatively transparent and easy to understand" (Copeland et al., 2000 p. 411). Likewise, the reader should avoid using extremely complicated valuation tools if they hamper an appropriate understanding of the value added by real options.

6/ CONCLUSION

The predominant appeal of real options theory is its factoring of the value of flexibility that the traditional approaches ignore. The traditional net present value approach assumes that there is only one possible outcome. It does not take into account possible adaptive actions that could be taken by corporate managers. Real options fill this gap.

But do not get carried away, as applying this method can be quite difficult because:

- not everyone knows how to use the mathematical models. This can create problems in communicating findings; and
- estimating some of the required parameters, such as volatility, opportunity costs, etc. can be complicated.

If not properly applied, real options can give very high values. In turn, these can be used to justify the unjustifiable, e.g. stock prices during the Internet bubble in 2000 or UMTS licences in 2001.

Their main advantage is that they force users to reason "outside of the box" and come up with new ideas.

SUMMARY

@ download

Traditional risk analysis methods are all based on the principle of net present value. They are applicable when all investment decisions are irreversible and projects have no flexibility.

With breakeven analysis, the manager or the analyst tries to understand the level of output and revenues that must be reached in order to break even. It is an important tool for a manager because it can set very clear targets. It is convenient to use this method by considering all fixed costs, including financial expenses.

Sensitivity analysis allows the manager to understand how sensitive the NPV is to changes in assumptions on key value drivers, while holding everything else constant.

Scenario analysis changes multiple assumptions simultaneously. In this manner, the analyst must make some effort in estimating which variables move together as well as the intensity of their relationship. Using the Monte Carlo method, a better idea of the prospects of flows can be obtained by allocating a probability distribution to each of them. Although powerful, the method is not so easy to interpret and can be misused.

The limitations of all these methods become evident when project managers are able to use new information to modify a project that is already under way, i.e. when there is a certain amount of flexibility. In such cases, the industrial manager is in the same situation as the financial manager who can increase or decrease his position in a security given predetermined conditions. An industrial manager can also be compared to a financial manager who holds an option. Flexibility of an investment has a value – the value of the option attached to it. This concrete property of a flexible investment is a real option.

Three factors are necessary to ensure that an investment project actually offers real options:

- there is some uncertainty surrounding the project;
- there is additional information arriving over the course of time; and
- it must be possible to make significant changes to the project on the basis of this information.

A number of different types of real options can be present in investment projects:

- the option to launch a new project;
- the option to expand, reduce or abandon the project; or
- the possibility to defer the project or delay the progress of work.

The study of investments on the basis of their net present value can be expanded, thanks to the concept of the real option. The result we obtain by including real options in the analysis is known as expanded net present value. This is the sum of the net present value of the project and the real options attached to the project. The uncertainty inherent in the flexibility of an industrial project creates value, but this uncertainty declines as time goes by. The uncertainty is replaced by the intrinsic value arising from the discounted flows adjusted for the new information.

QUESTIONS

@ *quiz*

1/How does using different scenarios differ from simple cash flow discounting?

2/In a simplified form, can the Monte Carlo method be implemented without a computer?

3/What does the theory of options contribute to the valuing of an investment?

4/Is the theory of options opposed to the theory of efficient markets?

5/Can a project that contains significant real options be valued properly by the NPV criteria? By the construction of scenarios? By the Monte Carlo method? By the certainty equivalent method?

6/Provide an example of a project where there is an option to abandon.

7/Provide an example of a project where there is an option to expand.

8/In practice, what is the most serious problem raised by real options?

9/What makes the contribution of real options attractive for operations managers?

EXERCISE

1/ An Internet portal aimed at pet owners has just developed a nuclear sewing machine and offers you the opportunity to invest in the industrialisation of this product. The project will last 5 years, and for 4 years, you will not be paid a dividend. But if the company is floated on the stock exchange after 5 years (which is the plan) you will get €5m. The founders of the portal estimate that your initial investment will be about €2.5m.

What return will this project bring you?

Given the project's risk, you decide that you require a return of more than 20%. What investment do you offer?

The founders, keen to obtain the €2.5m in question and believing firmly in the success of their project, offer you the following arrangement: you give them €2.5m and, if all goes well, you'll get €5m after 5 years. If the project fails, then they'll give you €1m after 5 years out of the €2.5m you invested. They believe that this reduces your risk considerably. How would you go about tackling this problem (without doing any calculations)?

ANSWERS

Questions

1/ *The assumptions are obvious.*
2/ *No.*
3/ *The valuation of management's margin for manoeuvre.*
4/ *No.*
5/ *No, no, no, no.*
6/ *Definitive closure of a mine.*
7/ *Buy a plot of land that is too big for the plant to be constructed, in order to be able to cater for a growing market.*
8/ *Valuing the alternatives.*
9/ *They highlight flexibility and the ability to adapt to a new environment.*

Exercise

1/ *IRR = 14.87%. Around €2m. The founders' offer could be compared to a put option on the project with a strike price of €1m. The whole problem lies in the valuation of this option (the volatility of the value of the project must be appreciated). The founders value it at €0.5m. The option that they're "offering" you does in fact reduce your risk, since your loss is now limited to €1.5m compared with €2.5m previously.*

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