Valuing strategic investment decision: Real options analysis

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ملخص

يحاول هذا المقال عرض نظرية الخيارات الحقيقية باعتبارها أسلوبا جديدا في تقويم القرار الاستثماري. كما تحاول تقديم حل جيّد للمشكلات المرتبطة بعدم التأكد التي تعجز الطرق التقليدية القائمة على التدفقات النقدية المخصومة على حلها. فأسلوب الخيارات الحقيقية في تقويمه للمشاريع الاستثمارية وجود سلسلة من القرارات الاستثمارية الدينامكية المستقبلية التي تملك فيها الإدارة المرونة الكافية للتكيف مع المتغيرات التي قد يشهدها محيط الأعمال. و لكن عيب نماذج الخيار الحقيقي هذه يكمن في تعقيدها الأمر الذي يجعلها صعبة التطبيق في الواقع.

الكلمات المفاتيح: الخيارات الحقيقية، الطرق التقليدية، القرار الاستثماري، تطبيق الخيارات الحقيقية.

Résumé

Cet article présente une nouvelle méthode de choix d'investissement; une technique plus dynamique et plus flexible que la VAN classique dite technique des options réelles. Du point de vue des options réelles, une stratégie d'investissement consiste en une série ou un portefeuille d'options dynamiques où les acteurs sont amenés à gérer de manière proactive la séquence et la temporalité de leurs décisions. Cependant l'inconvénient des modèles d'options réelles est leur complexité qui rend, souvent, impossible leurs applications sur les situations du monde réel.

Mots clés : Options réelles, méthodes traditionnelles, décision d'investissement, application des options réelles.

Abstract

This paper examines a novel/ new means of evaluating investment decisions. A technique that can provide a good solution for the uncertainty problem that traditional discounted cash-flows-based methods cannot solve. When the outcome of an investment is least certain, real options have the greatest potential analytic value. Real options assume a dynamic series of future decisions where management has the flexibility to adapt to changes in the business environment. However, the drawback of the real options models is their complexity which frequently makes them impossible to apply in real world situations.

Keywords: Real options, traditional methods, investment decision, real options application.

1. Introduction

Given the rate of technical change, the industrial restructuring associated with globalization, and the long time horizons associated with significant investments, it is simply impossible to forecast future conditions accurately. Consequently, managers need solid methods for valuing prospective investments, so they can justify their development strategies.

Their fundamental problem is compounded by two methodological difficulties: (a) traditional net present value (discounted cash flow) evaluations are inadequate for many risky projects, and (b) the available methods for valuing these projects are limited and often impractical. However, the ability of managers to make smart decisions in the face of volatile market and technological conditions is essential for firms in any competitive industry.

Faced with uncertain decisions, managers intuitively know they have the option to defer, stage, abandon or expand a project, or even switch funds to a more profitable financial opportunity, yet the traditional static discounted cash flows framework of capital budgeting fails to take such managerial flexibility into account. This flexibility (1) can represent a substantial part of the value of many projects. Neglecting it can grossly undervalue these investments and induce a miss-allocation of resources in the economy.

This paper considers a novel means of evaluating the investment decision. It suggests that using Real Option analysis is both reasonable conceptually, and a practical, efficient way to value risky projects. However, the use of real options models by managers appears to be limited. Users of real options models should understand the quantitative aspects of these models, and may often need to create a customized model for each situation.

Thus, the questions that could be asked are:

1- What is the real options approach to capital budgeting?

2- How can real options be superior to the traditional NPV method?

3- To what extent the real option analysis can be applied in real world?

The paper is trying to answer the above questions by explaining the inadequacy of traditional methods for valuing risky projects, focusing on the significance of real options to investment analysis, the analogy between real options and financial options as well as some typical types of real options. The paper then provides an insight of real option valuation application in the investment decision making and the difficulties in implementing the theory. Finally, it introduces criticism and defense on the real options applications.

2. Inadequacy of traditional valuation methods for risky projects.

Discounted cash flow method (DCF) is the main approach to value projects in traditional methodology. Probably because it is intuitive and straightforward to apply, DCF method is used by most firms.

Discounted cash flow valuation is based on the fact that 1 monetary unit today is worth more than 1 monetary unit tomorrow. That is, cash flows associated with a project, even if they occur in future period, can be discounted at time value money to express their values at present time – their present values. The interest rate at which the cash flows are discounted is

also called rate of return and reflects the amount of risk associated with the cash flow [(2)]. For a series of cash flow CF_0, CF_1, $CF_3 \ldots CF_n$ occurring at time t_0, t_1, $t_2 \ldots t_n$, the value of the cash flows, present value (PV), is given by their discounted sum:

$$PV = \frac{CF_0}{(1+r)^0} + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n}$$

where CF = cash flow, r = discount rate, and

$$\text{Discount factor} = \frac{1}{(1+r)}$$

In order to compare projects that have different costs (investments amounts), it is useful to subtract the initial investment costs (I) from the present value, thus obtaining the net present value (NPV):

$$NPV = PV - I$$

If costs of the project are spread out over multiple of these cost time periods, then:

$$NPV = CF_0 - I_0 + \frac{(CF_1 - I_1)}{(1+r)^1} + \frac{(CF_2 - I_2)}{(1+r)^2} + \frac{(CF_3 - I_3)}{(1+r)^3} + \ldots\ldots + \frac{(CF_n - I_n)}{(1+r)^n}$$

$$= \sum_{t=0}^{n} \frac{(CF_n - I_n)}{(1+r)^n}$$

Investments subtracted from the sum of all present value occurring in a project give the net present value (NPV). The net present value calculation is the most common approach to value large investments. A naive application of the net present value calculation states that if a project has a positive present value, it should then be undertaken. It will raise the value of the firm, which is the financial objective toward the shareholders of the firm. The success and accuracy of DCF analysis is determined by the choice of concomitant discount rate. If chosen to high, the discount rate can lead to reject projects, as NPV will become negative. If chosen to low, projects might be accepted because they yield a positive NPV, which should not be positive [(3).]

The method is simple, yet concrete. However, it contains some methodological flaws.

2.1 Valuable information is lost:

The most challenging task in implementing DCF method is to estimate future cash flows. Firms usually rely on the experience and expertise of their analysts to predict future market conditions and come up with some reasonable estimation. It is important to note that despite lots of

efforts spent on estimating future cash flows and making them as plausible as possible, this prediction is at best, just point estimation(4). This by no means can accommodate the fact that the actual realization of future cash flows may deviate remarkably from this prediction.

In fact, future cash flows of a project should be considered as a stochastic process evolving according to some probabilistic rule. Conditioning on future events, there may be infinitely many possible paths for project payoff value. If we model this process with appropriate parameters, we can derive explicitly the distribution of the cash flow at any point in time.

By specifying the whole sequence of future cash flows with specific values, this stream is essentially just one out of thousands possible paths project payoff value can take (5). This point makes clear the flaws of DCF method because instead of considering the impact of all possible paths of future cash flows, analysts typically fix only one path which they believe most plausible and rely solely on it to recommend investment decision. No matter how good are they in prediction, this type of treatment is completely subjective and ignores much valuable information contained in other possible paths of the process. It may seriously affect manager's view over potential profit and risk of the project (6).

2.2 Project's risk nature is not static:

A second challenging task in DCF method is choosing an appropriate discount factor. Although it is theoretically possible to apply different discount factors in different periods, the usual convention is using one discount factor all along the life-time of the project. This discount factor is adjusted to reflect the systematic risks involved in the project. As a practical matter, if the project is in line with current businesses of the firm, firm's weighted average cost of capital (WACC) is a natural choice. If the project is new, this discount rate is adjusted to reflect idiosyncratic risks associated to that project (7).

Therefore, no matter how good are managers in choosing an appropriate discount factor today, assuming it remains constant throughout the lifetime of the project, is a mistake. As new information arrives, the risk profile of the project can change dramatically.

We admit that it is difficult to estimate the dynamics of the discount factor upfront, but our claim holds that it is methodologically wrong to assume it constant and make decisions at once. Because changing discount factor will certainly change the project value, we should take this fact into account and open a new way for our perception about project valuation and investment decision making (8).

2.3 Decision is not now-or-never:

In the DCF framework, managers typically make decisions whether to invest in a project by looking into only few possible paths of project payoffs value which analysts believed most plausible. The NPV rule then posits that a project should be carried out if its NPV is positive and abandoned if otherwise. And this is a now-or-never decision.

However, this strategy is often wrong. Given the possible change of estimated future cash flows and discount factor, NPV today may differ significantly from NPV tomorrow. Deciding to invest or abandon a project at once as posited in the NPV rule leads

managers to a very passive strategy and that can hardly be optimal in our dynamic world[9].

Therefore, the decision is not now-or-never. In many cases, holding decisions for few more periods leaves us a chance to observe how future uncertainties unfold.

The possibility for managers to adjust their decisions along the life of a project is usually called "managerial flexibility". This managerial flexibility in many cases is very valuable and should be taken into account upfront [10].

2.4 Investment is not completely reversible :

Managers should not blindly believe in DCF method and not watch out what is happening with their project. If something goes wrong, managers should reverse the investment immediately by selling it for some liquidation price.

This argument may hold for certain type of investment where market for installed equipments is active. An entrepreneur who has bought 100 cars to offer taxi service can easily sell his cars on secondary market should he change his mind. But for many other types of investment, the situation is not that easy. Once the project has started, the only way to reverse it is probably canceling the project and forgoing all granted expenses'. Indeed, for most types of investment, canceling a project usually requires managers to forgo substantial cost – which we call sunk costs [11].

Thus, most investments are fully or at least partially irreversible. Because the sunk cost is an inherent aspect of most of the capital investments, managers should be cautious in committing resources to a project. They have chance to wait for better information before making decision and that can help reduce the probability of loosing sunk costs. Deciding to invest today essentially kills this option.

The assumption that all investments are irreversible is a fundamental weakness of most DCF methods. Assuming that investment can be reversed without causing serious damage in value as posited in conventional DCF method and NPV rule usually overlooks this point[12].

Although NPV calculation only contains the endogenous value of a strategic investment, it has to be considered carefully because it can be regarded as the first step leading towards real options valuation [13].

3. Real options approach to investment analysis

Traditional methods are, in fact, inadequate to set up an effective investment strategy, but this is not to say that DCF and NPV rule is useless. Indeed, it has been and still deserves to be the main building block of any investment analysis. The criticism is only meant to highlight that we should not apply this rule in a static and passive manner as it is usually taught.

DCF techniques were originally developed in order to value investments such as stocks and bonds, and assume that companies hold investments passively. They overlook management's flexibility to alter the course of a project in response to changing market conditions. In effect, they assume that management makes an irrevocable decision based on its view of the future, and then does not deviate from its plan no matter how things actually shape up. The life of the project is assumed to be fixed, and the possibility of abandoning it in the face

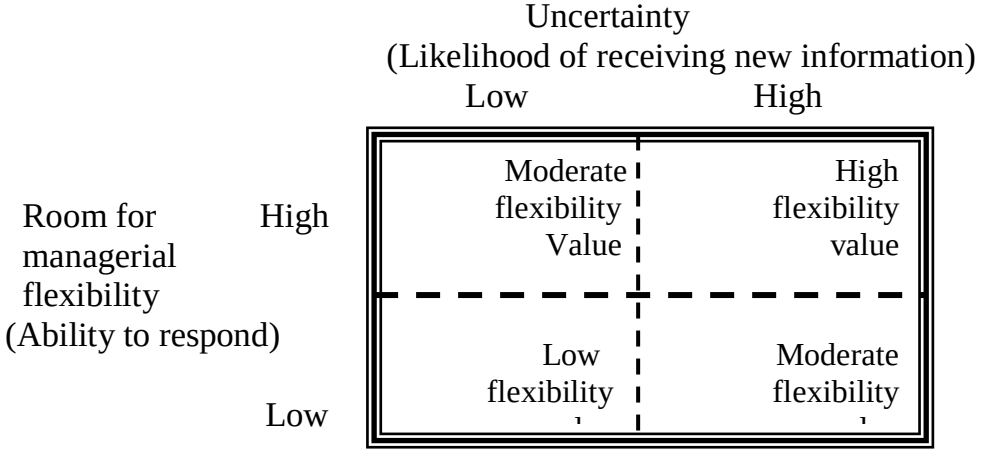
of adverse circumstances or, conversely, expanding it in response to unanticipated demand is not even considered(14) .

Because real options approach recognizes that risks can be managed, to avoid bad outcomes or take advantage of good ones as they become apparent, the use of real options practically always leads to higher values for the same project than the traditional methods, precisely because the options perspective recognizes that managers make future decisions about a project as uncertainties become resolved. They will terminate projects that are not working out, and expand on those that are performing well. Real options approach incorporates this avoidance of losses and exploitation of gains in the analysis and therefore necessarily leads to a higher perception of value of risky projects. This recognition and exploitation of the value of flexibility "unlocks" fundamental value in risky projects. The real options approach uncovers the contributions of active management, which is a commonly overlooked source of value (15).

Many investment projects have flexibility that is difficult to capture with traditional discounted cash flow methods. The real options approach frames the valuation process differently from the traditional methods. It views a project as a process that managers can continually reshape in light of technological or market changes (16). For example the opening of a new oil field involves a series of decisions about whether to lease an area, how to explore it, what wells and pipelines to build, and so on. This perspective contrasts with the traditional view of a project as set of decisions made once at the beginning and unchanged during the life of the project (17).

The manager may have the option to postpone the start of the project or to alter the project in some way either before or after the project has started. This type of managerial flexibility becomes important for the total value of the investment opportunity when there is uncertainty in the environment of the project. The higher the level of uncertainty, the higher the option value because the flexibility allows for gains in the upside and minimizes the downside potential (18).

Figure 1 : Value of managerial flexibility



Source: Thomas & Philip T. Keenan, How much is Flexibility Worth? www.mckinseyquarterly.com

As mentioned before, real options do not replace traditional DCF based methods but they augment them. In other words, it is important to stress that real options represent an extension, not an overthrow, of NPV. Real options accept the essential NPV insight – that value equals the sum of discounted future payoffs – but argue that the standard NPV framework is unable to correctly make this calculation when projects offer future managerial flexibility [(19)].

In all real options valuations the start point is the NPV analysis of a project. Real options valuations are most important in situations of high uncertainty where management can respond flexibly to new information. NPV is treated as the "value without managerial flexibility". A strong positive NPV provides no further advantage in waiting. Managers would be well advised to invest and capture early cash flows [(20)].

Where the project has a strong negative NPV (beyond the ability of the firm to easily bear), there is no justification for investing. Real options work best on marginal projects (zero, or marginal plus or minus NPV) or in staged investments where the upside value is very high but there is high risk and uncertainty. In such projects the value of the embedded options in each project are calculated for different degrees of volatility.

The total value of the project is therefore [(21)]:

Value of project = Value of project without flexibility + Value of flexibility
= NPV + Real-option value

What this means is that in attempting to value any project that contains a real option, we can either (i) incorporate the option payoffs into the project itself and value the project-with-flexibility directly or (ii) separately calculate the value of the option cash flows and add this to the project's NPV. The value-additivity principle tells us that the answer is the same. Although the choice of method is therefore immaterial to the ultimate decision, method (ii) is particularly helpful for illustrating the differences between net present value and real option valuation.

Using method (ii) the differences between these two approaches can be summarized as follows:

Net Present Value

NPV = [sum of project's expected cash flows discounted at a rate reflecting the risk of these cash flows] minus initial cost of project

Real Option Analysis

ROA Value = NPV plus [sum of real option's expected net cash flows discounted at a rate reflecting the risk of the option's cash flows]

Beside the conventional NPV, a new component measuring managerial flexibility is included. It is obvious from the above formula that depending on the situation, the options value component in expanded NPV may be even substantial enough to justify for a project with negative NPV in conventional sense. A typical example of this sort is R&D project whose purpose is not to generate cash inflows directly but rather to open ways for a firm to enter new markets or industries. By simple NPV rule, this type of project will never generate enough cash

to justify its expenses. Only because of the options component does a firm decide to invest in it.

Projects valued using the traditional discounted cash flows methods often provide a value that grossly understates the true fair market value of the asset. This is because projects may provide a low or zero cash flow in the near future but nonetheless be valuable to the firm.

There are a number of investments that may contain elements that could provide valuable opportunities to a firm in the future. As mentioned before some investments may not be profitable but for the attractive opportunities that they are capable of creating in the future.

These opportunities are highly valuable and must be identified while evaluating capital investments. Investments with potential future opportunities or flexibility are more valuable than investments without such strategic elements [(22)].

Real options are those strategic elements in investments that help creating flexibility of operations, or that have the potential of generating profitable opportunities in the future for the firm. Real options provide discretion to managers to take certain investment decisions, without any obligation, for a given price. We may clarify that real options are not confined to real assets only. Patent, R&D, brands etc. are examples of assets that have a value to the owner. The capital investments should be viewed as strategic investments that incorporate real options. Hence the value of a capital investment will also include the value of the strategic elements in the investment[(23).]Valuing real options is real challenge for managers, who must play an active role in identifying or creating options, valuing them, monitoring them and using them appropriately to create values for the firm. In other words, real options implies a dynamic decision-making process wherein the investor learns over time and makes different updated decisions as time passes and events unfold.

4. Real options are analogous to financial options

Myers was among the first to publish in the academic literature the notion that financial option pricing theory could be applied to strategic issues concerning real assets rather than just financial assets. In fact, the option pricing theory provides a framework for valuing strategic investments. The methods of valuing real options are the same as the financial options, although it is difficult to identify the values of certain inputs in case of real options[(24).]

The real options approach is simply an extension of financial options theory to non-financial assets. Most of analytical techniques employed in real options are based on the analogy between financial options and options on real assets, although transiting between two domains usually requires serious cautions in model and method calibrations [(25)] .

Trigeorgis defined real options as follow: “Similar to options on financial securities, real options involve discretionary decisions or rights, with no obligation, to acquire or exchange an asset for a specified alternative price”[(26)].

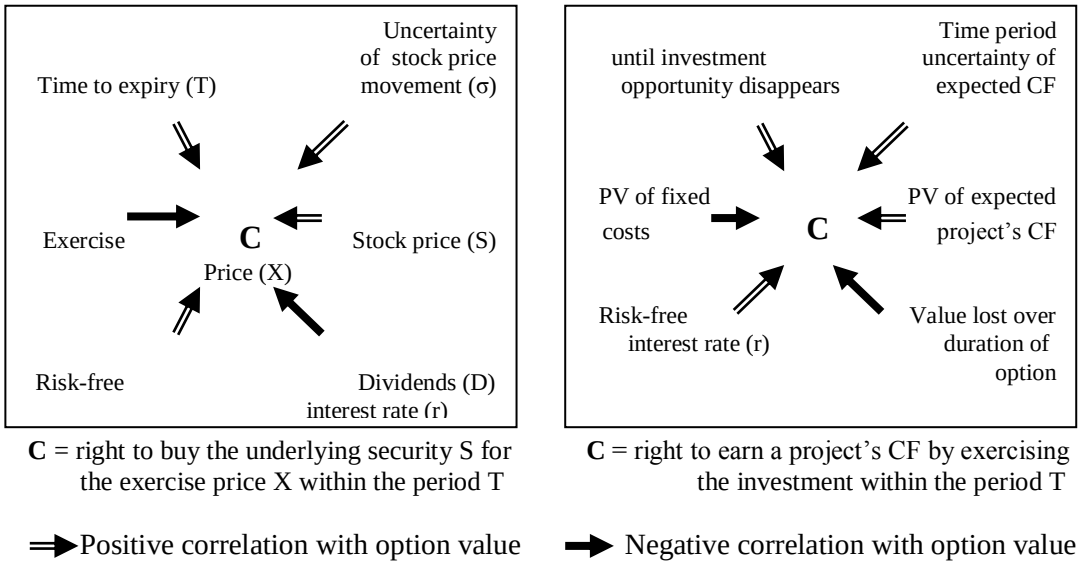
Managers’ options on real investment projects are comparable to investors’ options on financial assets, such as stocks. A financial option is the right, without the obligation, to purchase or sell an underlying asset

within a given time for a stated price. A call option gives the buyer the right, but not the obligation, to buy a security at a specified price in the future. The buyer of a call option is taking an optimistic view of the security underlying the call option. Similarly, a capital investment today that gives the investor the future right, but not the obligation, to make a further investment is a real option.

A "real option" deals with investments with options-like characteristics that are not traded as securities in financial markets. For instance, the capability to bring a new product to market (based on having invested in the necessary research and development) is a "real option". This capability enables a firm to produce the new product if the market is favorable, but does not oblige the firm to do so if the market is unattractive [(27)] .

Spending money to exploit a business opportunity is analogous to exercising an option on, for example, a share of stock. It gives the right to make an investment's expenditure and receive an investment's asset, the value of which fluctuates stochastically. The amount of money spent for investment corresponds to the option's exercise price (X). The present value of the project's asset (total gain of investment) corresponds to the stock price (S). The length of time the firm can defer the investment decision without losing the opportunity corresponds to the option's time to expiration (T). The uncertainty about the future value of the project's cash flows (the risk of the project) corresponds to the standard deviation of returns on the stock (σ). In general, the stock (σ) corresponds to the variation in the cost and revenues of the investment. Finally, the time value of the money is given in both cases by the risk-free rate of return (rf). The project's value as calculated by the real option methodology is the same with the value calculated by the Net Present Value (NPV) methodology when a final decision on the project can no longer be deferred (expiration date of the option)[(28)] . Figure 2 summarizes the parameters' correspondence between a call option and an investment project.

Figure 2 : Value drivers of financial and real option



C = right to buy the underlying security S for the exercise price X within the period T

C = right to earn a project's CF by exercising the investment within the period T

⟹ Positive correlation with option value

→ Negative correlation with option value

Source: The International Journal on Media Management 2002 Vol 4 No 4

Thus, we can see a firm endowed with a project as if it is given an option to acquire that project (the future cash flows generated from the project) in exchange for some price, which is investment cost. The firm can decide, at its own discretion, whether or not to exercise this option (i. e whether or not to invest) and when to do so. We can easily recognize the analogy between this real option and a financial call option. If financial options have value, so do real options [(29).]

Some capital investments have embedded options. Managers must recognize and value these options and exercise them when it is advantageous to do so. A firm can attain flexibility and make commitments by intentionally creating simple options into investment projects. It can obtain flexibility by creating long positions in call or put options. For example, right to expand or right to enter a new venture in the future at a given price is a long position in call option, and right to abandon or right to liquidate in the future at a given price is a long position in put option. Managerial commitments are akin to short positions in call or put options. A firm may agree to disinvest (short call) or invest (short put) contingent upon action of another party[(30).]

Managers of physical projects or products deal in real options all the time, even if they do not realize it. Real options are part of any development of a project or a product. They exist wherever and whenever investments involve strategic choices over time that managers can actively direct.

In short, whenever managers have the choice between different lines of development, and select one rather than some other, they are exercising a "real option". Most importantly, real options can be designed into projects and products. This can be done either conceptually, by realizing that a project can be staged; or physically, by building in flexibilities that enable managers to exercise options [(31).]

5. Types of real options

When valuing potential investment opportunities, managers would like to know what types of real options are associated with a particular investment/project.

The numerous types of real options can be classified into three main categories[(32)]: learning options, growth options and insurance options. Within these categories, we distinguish several options types.

The following table depicts an overview of these real options types along with the equivalent financial options.

Table 1 Real option types and their financial equivalent

Category	Option type	Equivalent financial option
Learning options	Option to defer Time-to-build option	Call option Compound call option (33)
Growth options	Option to expand Option to innovate	Call option Call option
Insurance options	Option to contract Option to shutdown and restart Option to switch Option to abandon	Put option Call option Combined call / put option Put option

Source: Stephan Schmidt Tank, Valuing Joint Ventures Using Real Options. ESCP-EAP Working paper No 7 September, 2004 p8.

5.1 Learning options offer management the opportunity to react to changes in the environment and to adapt investment strategies to new information that they may acquire at a future point of time. An option to defer allows management to wait to invest into a project and gather more information on the project; oil leases are an example for defer options. Time-to-build options exist when investments are staged, i.e, the firm can stop an investment project before making all the investments; research and development efforts are usually staged investments.

5.2 Growth options let the firm react to positive market or project developments, management may be able to expand their business activities in a market or their commitment to a project by making additional investments (option to expand). Firms can also acquire new knowledge or skills through investment projects, generating opportunities for follow-up projects based on three skills, i.e. options to innovate.

5.3 Insurance options can be found whenever a firm is able to react to (negative) changes in the market environment by adapting an existing investment project or abandoning it altogether. An option to contract lets management reduce the firms' activities once market conditions deteriorate. An option to shutdown and restart represents a special case of an option to contract, allowing the firm to completely shut down operations for a certain period and restart them as soon as the market environment improves. If management can put the firm's assets to another, more profitable use, it has an option to switch, i.e. exchange one investment project for another. Finally a firm can leave the market altogether and shut down operations permanently in exchange for the salvage value (option to abandon).

Real options are not mutually exclusive; investment projects can create types of options at the same time.

6. Application of real options

The real option model is an alternative approach towards the investment valuation. The model tries to capture in detail an important element of the investment decision

making-the uncertainty. It reveals the value of an investment project associated with uncertain market conditions and suggests the optimal investment strategies, e.g., the optimal timing, scale and technology.

The uncertainty could concern the future development of the markets and especially the uncertainty about the future development of the regulatory framework. The latter is often not fully captured in any of the traditional investment valuation model (such as the Discounted Cash flow Valuation).

6.1 Areas of real options application

There are multiple industries and sectors, where real option can be a more convenient valuation tool than traditional valuation tools. Since its inception, the real options valuation method has been proposed as an analytic tool for all types of investment problems- from natural resource investments and new products to start-ups, acquisitions, factories, information technology, and more.

The common characteristics of investment in these sectors are that they are expensive, long term, affected by multiple risks (market risk, regulatory risk, political and social risks, etc.) and are formed in large part from irreversible costs. Thus standard valuation methods cannot fully capture their real value and result in biased results.

Among the sectors, where real option valuation could be successfully deployed belong above all the following(34):

- Mining of minerals
- Pharmaceutical industry
- Research and development of hi-tech products (biotechnologies, nanotechnologies, etc.)
- Information and telecommunication technologies
- Aeronautics
- Energy production and transmission

Earlier applications are focused on natural resources investment opportunities. Exploitation of minerals is a very resource-intensive and expensive activity. Opening of new mine takes preliminary works on geological exploration, negotiation of licenses and contracts, investments in heavy machinery are large expenses that are from major part irreversible. Development of a new mine or operation of an existing one is a long run project that is subject to several types of uncertainty including the volatility of prices of the mined commodity, changes of environmental, labour and other regulation, technological shocks, etc.

Pharmaceutical industry and any sector manufacturing hi-tech products (such as biotechnologies, nanotechnologies, etc.) are heavily dependent on research and innovation. However, research is an expensive, long-term activity with uncertain results. Besides due to rapid development in these sectors, the product prices might be volatile and making revenues from any project uncertain.

In information and telecommunication technologies, the rapid development of the industry is a principle cause of the uncertainty of investments in this sector. Companies in this sector have to be quick in developing new products in order to stay ahead of its competitors, but the tough competition causes that the revenues from new products in the

sector are to predict, uncertain, respectively.

Aeronautics is a sector characterized by extremely long and extremely costly project development. Design, construction and testing of a new type of airplane take years, the revenues in the sector are volatile and the competition in air transport is tough. Thus the conditions for application of real option are fulfilled in this sector[(35).]

A vacant land in the real estate industry can be seen as an asset bearing options, since the owner can decide the timing and type of building for the development. A forest is an option asset because the harvest schedule can be planned optimally to maximize its economic value.

Not only investment opportunities but also the capital structure of a firm can be analyzed with real options theory .Trigeorgis applied real options to analyze credit risks that are encountered by financial institutes. Strategic planning can also be seen as a collection of real options [(36).]

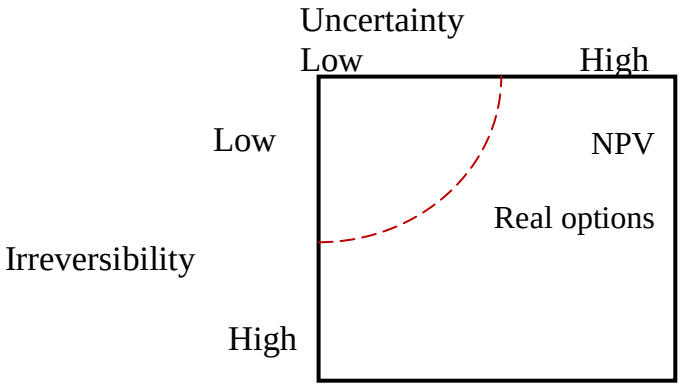
6.2 General conditions of real options application

The real option approach may have substantial advantages compared to the traditional valuation methods, however, Scholleova suggests that on certain types of situations it cannot be applied. These situations can be summarized as follows [(37)]:

- Decision making under certainty or zero risk; in this case the option value disappears and the real option valuation equals to DCF
- Decision making that cannot be postponed or modified; the real option that measures flexibility does not have sense when flexibility is not possible
- Twin options, when the option value would be assigned to more interdependent projects; in such a case, the real option would over-valuate the flexibility
- Low budget projects where the estimated option value would exceed the total costs of the projects

Figure 3 adopted from Adner and Levinthal depicture graphically and simpler the limits of use of the real option model. In case that the investment does not contain a significant share of irreversible costs and/or is not tightly bound to uncertain factors the use of real option is unnecessary.

Figure



Source : Adner, R.; Levinthal, D.A. (2004 What is Not a Real Option: Considering Boundaries for the Application of Real Options to Business Strategy; Academy of Management Review; Vol. 2004; No. 29, p 85

In case of low degree of uncertainty and irreversibility, the NPV rule is more appropriate than real options. Flexibility means that when the option expires, the firm really has the possibility to choose among several alternatives. If there is no other viable alternative, the investment project is a "bet", not an option. On the other hand, if the scope of opportunities is too wide, (either from a technological or from a market perspective) the decision process is more characterized by path dependence than by option logic. Whereas the real option approach requires specifying ex-ante the possible project scenarios, exploration activities are difficult to anticipate (38).

According to Mun, before starting the analysis of real options, analysts should be aware of the following requirements that must be met before it is conducted (39):

❖ There must be a financial model. The analysis of real options requires the use of an existing model of discounted cash flows. If there is no such model, it means that strategic decisions have already been made and no financial justification is required.

❖ There must be uncertainty. Otherwise, an option is worthless. If we know everything "upfront", in this case the model of discounted cash flows is sufficient.

❖ Uncertainty must affect decisions made by a company during the realization of a venture as well as it must affect the results of the financial model. The appearing uncertainties will become risk then real options may be used to secure the risk of failure

❖ The manager must have the possibility of flexible decision making or the possibility of implementing changes during the active realization of the project. We cannot use the concept of real options in case there are no options or flexibility in managing the value

❖ The decision –maker must be predicting and credible enough to realize an option at the optimal moment. In other words, all existing options are useful when they are realized in proper time and in appropriate conditions.

Once the practitioner decides that ROA is the right tool for the project under consideration, a five step process can be used to calculate and analyze the option value for the project. (e.g., binomial method) (40).

- Frame the application: Framing a real option is more difficult than framing a financial option. It involves describing the problem in simple words and pictures, identifying the option, and stating clearly the contingent decision and the decision rule. Trigeorgis divided the real options into seven categories according to the differences in flexibility: Option to defer, staged investment option, option to alter operating scale, option to abandon, option to switch, growth option, and interacting option.

Some applications involve more than one decision or option. For example, chooser options may include abandon, defer, expand, contract, and other options. Compound options involve options on options, which may be parallel or sequential. We must identify these dependencies very clearly. Keeping the problem simple and making it more intuitive will help us communicate the results more effectively to get upper management's buy-in.

- Identify the input parameters: The basic input parameters (for the

binomial method as an example) to value any type of option include the underlying asset value, strike price, option life, volatility factor, risk free interest rate, and time increments to be used in the binomial tree. Additional information is required for some of the options, such as expansion and contraction options.

- Calculate the option parameters: The option parameters are intermediates to the final option value calculations and are calculated from the input variables.
- Calculate the option value: Real options analysis (ROA) is far more complex compared to these traditional tools and requires a higher degree of mathematical understanding. There are several techniques to evaluate the options as shown in table(2).
- Analyze the results: After the option value has been calculated, the appropriate first step is to compare the net present value derived from the DCF method versus ROA and evaluate the value added as a result of the flexibility created by the option(s).

Table 2 Option valuation techniques

Option valuation techniques	Specific method
Partial differential equations method)	- Closed form solution using Black-Scholes and Other similar equations - Analytical approximations -Numerical methods (finite difference
Simulations	Monte Carlo
Lattices	- Binomial - Trinomial - Multinomial

Source: Kodukula, Prasad., & Papudesu, PMP Chandra. (2006). Project Valuation Using Real Options: A Practitioner'sGuide. J. Ross Publishing, U.S.A.

6.3 Real options application in real world

Despite a large body of literature on the topic, empirical tests of real option models are scarce. The complexity of real options models makes them frequently impossible to apply on real world situations. Therefore in the managerial decision making more widely used versions of the real option model are those based on the simplified approach of Cox, Ross and Rubinstein(41).

Recent evidence, in fact, suggests the valuation technique may be losing traction. In 2000, Bain & Company conducted a survey of 451 senior executives across more than 30 industries regarding their use of 25 management tools. Just 9% used real options, which ranked next to bottom on the list (only market-disruption analysis, a "new economy" technique, scored lower). And whereas the average defection rate for all tools in the study was 11%, 32% of real-options users abandoned the technique in 2000. Only two other tools had higher defection rates. Meanwhile, discouraging news also came from a 2002 survey of 205

Fortune1,000 CFOs by Colorado State University professor Patricia Ryan. That survey found real options trailing a field of 13 "supplementary" capital-budgeting tools. Only 11.4% said they used it, compared with 85.1% for sensitivity analysis and 66.8% for scenario analysis. As for "basic" capital-budgeting tools, net present value (NPV) topped the list at 96% [(42).]

Another survey conducted by Block of fortune 1000 companies whether they picked up real options to complement traditional analysis, application and percentages of usage among industries were different.

Table 3 Real option usage in different industries

Industries	No	Application fields	%
Beverages	3		
Energy	25	New product introduction	36.2
Finance	31	Research & development	27.8
Food processing	9	Mergers or acquisitions	22.1
Health care	26	Foreign investment	9.6
Manufacturing	57	Other	4.3
Publishing	5		100
Retail	44		
Technology	36		
Transportation	12		
Whole sale	9		
Utilities	22		
	279		

Source: Block, Stanley. (2007).Are real options actually used in the real world?. The engineering economist, 52(3).http://dx.doi.org/10.1080/00137910701503910.265-267

He also investigated the most used methods for solving real option. As table 4 represents Binomial lattice is the most popular approach in real option valuation due to simplicity of usage and explanation to top management

Table 4 Techniques for using real option

Binomial lattices	16
Risk-adjusted decision trees	12
Monte Carlo simulation	9
Black-Scholes option pricing model	1
Other	2
	40

Source: Block, Stanley. (2007).Are real options actually used in the real world?.Ibid

6.4 Empirical studies

As noted before, empirical studies on the implementation of real options are still rare, and research remains relatively silent on how to concretely apply real option theory. Yet, a few case studies inspired by real investment decisions underline the benefits of real option for strategic decision making and illustrate the wide range of potential applications of real option. In capital intensive industries such as the petroleum industry, which are comfortable with sophisticated capital budgeting decision tools, real options are evaluated with complex models, often in combination with decision analysis approaches (e.g.,Chorn & Shokor, 2006;Smith& McCardle, 1999), in order to make decisions on exploration investment projects(43).

In other industries, case studies demonstrate that real options can be particularly useful in determining the optimal investment taming- for example, for the market introduction of a new product in consumer electronics (Pennings & Linr, 2000), for the deployment of a new banking IT system (Benaroch & Kauffman,1999), or for the development of residential housing (Rocha, Salles, & Garcia, 2007). In other instances, real options are used to evaluate an investment under uncertainty, such as the investment in a software platform (Taudes, Feurstein, & Mild, 2000), in environmental mining equipment (Cortazar, Schwartz, & Salinas, 1998), or in an R&D project (Pennings & Lint, 1997) (44).

Overall, existing empirical studies provide limited evidence of the benefits of real options in the resource allocation process. Indeed, they do not reflect the practice of firms, but are rather the result of pilot projects on the use of real options. In addition, case studies mainly focus on the valuation aspect of real option; they tend to overlook the benefits of real options reasoning and leave unexplored the cognitive and organizational difficulties in the implementation of real options.

7. Criticism and defense of real options

Real options theory has its root in the financial markets. However, the assumptions made for the financial markets may not be appropriate in other markets. This leads to criticism on the real options applications.

The first criticism on real options theory comes from the doubt about the validity of the no-arbitrage pricing approach in real assets. In financial markets, the no-arbitrage pricing approach is based on the usage of portfolios of traded securities to replicate the payoff of an option. Since most underlying assets in real-life investment projects are not tradable, the no-arbitrage principle seems to be losing its foundation.

Mason and Merton argue that the justification of real options resembles the correctness of using NPV. A DCF analysis attempts to determine the value of an asset or a project as if it were to be traded. We identify for each project a twin security which has the same risk characteristics and is traded in the financial markets, and use the market required rate of return as the discount rate (45).

According to Trigeorgis the asset owner can, in principle, replicate the returns of a real option by a portfolio including shares of its twin security and risk-free bond. For the no-arbitrage principle to hold in a non-traded project, the option value must be the

no-arbitrage value of the option on its twin traded security. The only adjustment needed is to reduce the equilibrium rate of return expected in the financial markets by a risk rate-of-return shortfall, a dividend-like adjustment. This is just the risk neutral valuation of the real assets(46).

Dixit and Pindyck argue that the use of contingent claims requires the complete market assumption, i.e., stochastic changes in the underlying uncertainty must be spanned by existing assets in the economy. The assumption of spanning should hold for most commodities, which are typically traded on both spot and futures markets, and for manufactured goods to the extent that prices are correlated with the values of shares or portfolios (47).

The second criticism concerns the choice of a stochastic process for the underlying asset price. In a Black-Scholes setting, the underlying asset price assumed to follow a continuous process. However, in a real asset, this assumption may be violated. For example, jumps may occur in prices. In this case, a deep-out-of-the-money option may be underestimated. A Geometric Brownian motion may not be a good approximation for the underlying. This problem can be overcome by employing more realistic models that implicitly account for the non-standard price distributions. For example, we can use a jump diffusion model, a regime switching model.

The third criticism concerns the exercise property of a real option. The exercise of a financial option is instantaneous, i.e., when the action is taken, the ownership transferred to the buyer. Real options cases are much more complicated. The exercise of a real option may involve the need to build a plant or to drill a bunch of wells. And these actions may take years to be completed. In this sense, the lifetime of some real options may be less than the stated life.

In some defending arguments against this criticism, real options model is thought to be able to factor in the technical need to incorporate the real exercise properties. In valuing the investment opportunity, the reduced lifetime adjustment are considered(48) .

Real options techniques are regarded, mainly by practitioners, as a "black box", due to the sophisticated mathematics, e.g., Partial Differential Equations, in real options, and the consequent lack of transparency and simplicity. But thanks to the increasing power of computers, commercial software vendors offer many user-friendly applications of complex

real options.

Despite all we have said about real options it still a very promising field of both research and application. We know that it took decades for NPV to become widely accepted in practice, real options is an even more sophisticated tool. It too is going to take a few decades to be well integrated in corporations. Most companies have been using real options only since the mid-1990s.

8. Conclusion

While traditional discounted cash flow approach assumes a single decision pathway with fixed outcomes, and all decisions are made in the beginning without the ability to change and develop over time. The real options approach considers multiple decision pathways as a consequence of high uncertainty coupled with management’s flexibility in choosing the optimal

strategies or options along the way when new information becomes available. That is, management has the flexibility to make midcourse strategy corrections when there is uncertainty involved in the future. As information becomes available and uncertainty becomes resolved, management can choose the best strategies to implement.

Real options provide additional insights beyond the traditional analyses. At its least, real options provide a sobriety test of the results obtained using discounted cash flow and, at its best, provide a robust approach to valuation when coupled with the discounted cash flow methodology.

One of the problems encountered in real option valuation is the lack of ability to recognize them in reality. Other problems are related to the calculation procedure. It requires the use of complicated formulas which can be understood only by people with advanced mathematical Knowledge and adoption of sometimes unclear and quite rigid assumptions. They demand that managers have specific mathematical skills without which they are unable to deal with them and to use their full potential. A certain constraint in the use of the ROV concept is the need for very good historical data that generally only exist in financial markets for typical assets that are subject to systematic trading.

References and endnotes:

1- By flexibility we refer to the ability to make decisions at different stages in time. Generally, decisions depend on what has happened at previous stages. The absence of flexibility means that all decisions must be made initially. The difference in value between these two approaches is called the value of flexibility.

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