Assessment of Investment Project Profitability In Uncertain Environment: A Real Options Approach

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Abstract

Investment projects are the key to a raising and developed economy. The choice of these projects is very crucial and difficult. Therefore, a project's profitability assessment is necessary. This is not an easy task given the multidimensional aspects of an investment project. It must be based on a reliable method or a combination of methods; that can take into account the project's particularities and assemble the risks that may occur in its lifetime. This paper presents a literature review of all the project evaluation criterion in a certain and an uncertain environment, with an explicit discussion of their characteristics and a comparative analysis of their application. In addition, a general approach for the measurement of the profitability of an investment project in an uncertain environment is proposed as a guideline for a theoretical approach.

Keywords
Investment Project, Uncertain, Measurement of the Profitability, Real Options.

1. Introduction

The measurement of the profitability of an investment projects is a very complex exercise. It's highly reliable on the economic context and the world's changes. This makes it mandatory for decision-makers to assemble and build a strong methodology to monitor the particularities of each project, and to be able to make the most out of it. This is not a simple task, given the numerous criterion of measuring the profitability that exist, plus the complexity of the environment that brings uncertainty. Therefore, managers can no longer rely on traditional methods and have to upgrade to some refined methods to do the job. This paper presents a literature review of all the profitability measurement methods that are used to determine a project's evaluation, and brings a discussion of particularities and the characteristics of each and every one of them. We'll start with a general presentation of important notions in the investment project field, and then we'll display a proper review of the criteria and their main advantages/disadvantages. We will also include a debate about the most commonly used ones, regarding their efficiency and their complexity. Later, we'll establish a general approach for the measurement of the profitability of an investment project in uncertain environment.

2. Literature review

In this chapter, we will elaborate the major project profitability evaluation measures in a certain and an uncertain environment.
First, we need to identify precisely the elements that characterize a project's identity. Investment's environments are distinguished by these factors: (i) Uncertainty (ii) Flexibility (iii) Irreversibility.

i. Uncertainty in general, is a generic term used to describe something that is not known. Often, investment decisions are based on the wrong side of uncertainty. This means that many projects are not taken into account because of the fear that they will not work, or that projects are planned for the worst possible scenario. The downside of uncertainty is often called the risk is defined as is the difference between the estimation and the reality. Part of the uncertainty can be resolved within time; it can also be solved by investing in information. Leaders add value to the company as they actively manage change while the uncertainty is resorbed. At present, financial markets have learned to manage the good and bad sides of uncertainty through the use of hedging instruments such as options (call & put). In infrastructure projects, the ability to manage uncertainty comes from the ability to cover risks by introducing flexibility in the design of projects (Ramirez, 1997) [1].
ii. Flexibility refers to the ability of a system to respond to unexpected changes; often the ability to meet planned or expected changes is designated as adaptability. For the investment's analysis, flexibility is defined as the given possibility for the investor to exercise the option or not (Ramirez, 1997) [1].
iii. A project is said irreversible if investment costs are irrecoverable in case of a bad scenario. So once the decision to invest is taken, it is difficult to turn back without losing at least part of the expenses and their recovery will be difficult (Ramirez, 1997) [1].

2.1. Investment profitability evaluation in a certain environment

We are going to examine the major project evaluation criteria in a certain universe. We will explain each one in details and show how to valuate it, and present its advantages and limits. The principal methods included in these part are:

- The Payback period
- The Net Present Value
- The Internal Rate of Return
- The Profitability Index

a)- The Payback Period

The definition of a project's payback period is the time required for the project's expected cash flow to repay the entire initial investment. Therefore, the payback period is a measure of a project's liquidity in the short term. The payback period, commonly called Payback, is easier to calculate and to understand than any other method. To calculate, simply add future cash flows and see how long it is possible to recover the initial investment. The investment will be acceptable only if the payback period is less than the limit set by managers.

One of the qualities of this method is its ease of use. Moreover, this criterion favors short-term highly profitable projects allowing companies to have cash faster. Nevertheless, several gaps make it a less interesting criterion; indeed, the payback does not use discounting cash flows and thus ignores the time value of money. Moreover, this criterion does not take into account the different risks associated with the project since it uses the same method of calculation regardless of project's nature and context.

b)- The Net Present Value

The Net Present Value method is the means of estimating the net value that a project adds for shareholders given a deterministic cash flow structure of the project and a known discount factor (Ramirez, 1997) [1]. In a simplified manner, simply discount the future net cash flows and subtract the initial investment using the following formula:

$$NPV = -I_0 + \sum_{t=n}^{t=1} \frac{CF_t}{(1+k)^t} \ (2.1)$$

With: I_0 = Initial investment. CF_t = cash flows in period t. K = discount rate.

The NPV is the most commonly used method in financial analysis in companies. It helps the management tell if the investment will add value to the company. Also, it acknowledges the time value of cash flows.
However, it requires that the whole project's structure needs to be known at the beginning and the discount factor needs to be constant over the lifetime of the project; which is not always the case. Moreover, NPV does not consider the risks and the uncertainty associated with the projects. It ignores the value of flexibility and doesn't authorize a deviation from the original scenario making it impossible to achieve an active strategic management as pointed by (Myers, 1984) [6], (Lander & Pinches, 1998) [7], (Brennan & Schwartz, 1985) [8]. (Kester, 1984) [9], (McDonald & Siegel, 1986) [10], (PINDYCK, 1991) [11], (Trigeorgis, 1993) [12]; all pointed out that NPV modeling ignores and undervalues the flexibility of real asset investment. To quote Dixit and Pindyck: The simple NPV rule is not just wrong; it is often very wrong [11].

c)- The Internal Rate of Return (IRR)

The internal rate of return (IRR) is the discount rate that makes the NPV equal to zero. Many describe the IRR as the break-even discount rate (Broyles, 2003) [2]. The purpose of this selection criterion is to determine a single rate of return that synthesizes the project value.

To calculate this rate, simply find the appropriate rate that cancels the NPV following this formula:

$$NPV = -I_0 + \sum_{t=n}^{t=1} \frac{CF_t}{(1+IRR)^t} = 0 \ (2.2)$$

With: I_0 = Initial Investment. CF_t = Cash flow for the period t. IRR = Internal Rate of Return.

Since NPV equals zero means no value is created or lost, so these calculations are used to determine the project's profitability. Once the rate is determined, we must now be able to judge the quality of the investment. The decision will be made by comparing the internal rate of return with the minimum rate of return required by shareholders. In the case where the IRR is greater than the required rate, the investment is profitable and considered in the investment otherwise should be rejected.

The IRR is one of the best alternatives to the NPV. If the NPV is largely dependent on the discount rate, the IRR has the advantage of being only related to a given project studied. Plus, managers and analysts seem to prefer talking efficiency rather than monetary value as in the case of net present value.
Although easy to use, the internal rate of return is incalculable in certain situations and could also lead to suboptimal decisions. Moreover, as the NPV, IRR does not consider flexibility (Ramirez, 1997) [1].

d)- The Profitability Index (PI)

Profitability Index is simply the Present Value of a project divided by the required Investment. Constrained by capital rationing, a company must set priorities and choose the projects that make the best use of the limited funds available. The objective is to maximize value per unit of scarce funds (Broyles, 2003) [2].
A natural way to choose projects subject to capital rationing is to rank them in the descending order of their Profitability Index (PI) values:

Profitability Index = Present Value/Investment

$$PI = \frac{PV}{I} \ (2.3)$$

I represent the required investment during the capital-rationed period.

So, the projects with higher PI make better use of the available capital, creating value for the shareholders.

2.2 Project investment profitability assessment in an uncertain environment

It's very difficult to be certain of future cash flows of a project in a very changing environment. Under uncertainty, managers cannot accurately forecast either the expected cash flows or their standard deviations. Thus, project managers need to be aware of the risks and try to quantify it in order to be able to predict the future changes and determine the factors involved in influencing the growth of the profitability of the projects.
Uncertain environment is a very interesting field of study of multidimensional possibilities. In this part, we will introduce the most known methods of risk's quantification. We will show that proactive flexibility can create value and maximize the gains.

a)- The Sensitivity Analysis:

Sensitivity analysis is quite widely used by companies to explore the effects of such risks on large capital projects. The analyst changes one variable at a time (for example, price, volume, direct costs, etc.) to ascertain where the project's NPV is most vulnerable. The analyst must judge how much to change each variable. In principle, the degree of change should reflect the analyst's view of the combined effect of both inherent risk and estimation error on its variance.
In practice, such judgments are largely subjective and involve their own estimation error. The strength of this approach is that it enables consideration of specific ways to alter the project to reduce its risk, but it does not provide a basis for determining the discount rate (Broyles, 2003) [2].

b)- The Scenario Analysis

Scenario analysis is a more refined method that changes the different variables simultaneously to reflect alternative assumptions about future economic and business conditions.
Whereas sensitivity analysis highlights risks that are unique to the company and the project, scenario analysis focuses on systematic macroeconomic risks that also affect shareholders' diversified portfolios.
Used properly, scenario analysis can help to estimate the systematic risk that determines discount rates for projects (Broyles, 2003) [2].

c)- The Decision Trees

Decision tree analysis is a method of examining sequential decisions that are subject to uncertainty in the future (Chance & Peterson, 2002) [3]. The decision tree is a directed graph that represents the sequence of decisions and events. Among the nodes of the graph, there are decisions nodes and nodes of uncertainty. A decision node is represented by a square and leads to an event node. An uncertainty node is represented by a circle and has a choice between several events. The root of the decision tree is always a decision node (Ramirez, 1997) [1]

An NPV and a probability are attached to each event. For each node decision, the most favored decision is the one that leads to the node with the highest NPV. Calculations are going up the tree from the leaves to the root [1].
Decision trees calculate the maximum expected NPV rather than just the expected NPV based on a serial of optimum circumstances (Galli & Armstrong, 1997) [13].

An advantage of using decision tree analysis is its transparency. It does not involve a black box of analytical calculations; it is laid out for all to see. This ability to illustrate the decision points and the uncertainties in a concise, clear form makes the decision tree analysis attractive. The base of the tree is the decision made today. That decision can be: make an investment, decide how much to invest, or wait (Chance & Peterson, 2002) [3]. Decision trees take into account the value of flexibility in the structuring of the problem so that all uncertainties and sequential decisions are explicitly represented.
Nevertheless, the structures of the problem could be very confusing because of the complexities introduced by uncertainty, given the size of decision trees that can explode quickly to become complex and difficult to read (Ramirez, 1997) [1]. We would like to note, however, that a decision tree is not necessarily much different from a standard NPV analysis. Effectively both techniques use a single discount rate to value all project decisions (Chance & Peterson, 2002)

[3]. In a sense, decision tree analysis is like a standard NPV analysis that includes a project review at future decision points (Chance & Peterson, 2002) [3].

d)- The Real Options

Real option's definition is the Right to make favorable future choices regarding real asset investments (Broyles, 2003) [2]. The methodology of real options is still unknown by many project managers, yet this approach is derived from financial options.

To use the value of real options as a selection criterion, a project must fulfill these conditions:

- Initially, the investment costs are not fully or partially reversed.
- The second condition requires that the project must include sources of uncertainty.
- Finally, the last condition requires the presence of flexibility in decisions taking.

Real options are very similar to the financial options but it is important to pay attention to the specific details of each as shown in table below.

Table 1. Analogy between a financial option and a real options.

Financial option	Project characteristics
Stock price	Present value of expected cash flows
Exercise price	Present value of investment outlays
Time to maturity	Length of deferral time
Risk-free rate	Time value of money
Variance of stock returns	Volatility of project's returns

Many authors have identified several types of RO that can be used for investment projects. Table 2 summarizes and explains the most widely recognized and used Real Options that are:

- Abandonment (European Put option)
- Growth
- Right to defer (American call)
- Flexibility to switch
- Enter and Exit
- Time-to-build option (staged investment)
- Multiple interacting options

Table 2 also assembles the specifications and the research studies done on these types of Real Options, as references.

Table 2. Types and definitions of Real Options.

Real Option Type	Definitions	References
Abandonment (European Put option)	The option to sell or stop the use of a project. The value that can be regained by selling the project (salvage value) is included in the pricing of the project and can substantially alter the project's NPV calculation.	Bonini (1977); Myers and Majd (1990); Berger, Ofek, and Swary (1996) [14].

Growth	Growth options are strategic options. They are particularly relevant for projects which are not advantageous in themselves but may generate lucrative opportunities in the future. This type of option can especially be found in R&D.	Myers (1977); Kester (1984, 1993); Trigeorgis (1988); Pindyck (1988); Chung and Charoenwong (1991); Kemna (1993); Brealey and Myers (1996); Grenadier and Weiss (1997); Chatwin, Bonduelle, Goodchild, Harmon,and Mazzuco (1999) [15].
Right to defer (American call)	To delay an investment until the time is more profitable. This option is of special use for firms in volatile capital markets: The NPV increases as interest rates decrease and it may be optimal to invest at a later point of time.	Tourinho (1979) [16]; Titman (1985); Mc- Donald and Siegel (1986); Majd and Pindyck (1987); Paddock, Siegel, and Smith (1988); Pindyck (1991, 1993); Ingersoll and Ross (1992); Quigg (1993); Østbye (1997)
Flexibility to switch	A classic Option. It's the option to alter output or input to react upon changed market conditions.	Kulatilaka (1988, 1993) [17]; Kulatilaka and Marcus (1988); Triantis and Hodder (1990); Kulatilaka and Trigeorgis (1994)
Enter and Exit	This is the option to react upon a changing market and to expand operations (favorable market conditions) or to scale down operations (unfavorable market conditions). Such an option can be implemented when a firm wants to introduce a new product or would like to enter a new market.	Robichek and Van Horne (1967) [18]; Brennan and Schwartz (1985); Mc- Donald and Siegel (1985); Trigeorgis and Mason (1987); Pindyck (1988); Dixit (1989, 1992); Majd and Pindyck (1989); Myers and Majd
Time-to-build option (staged investment)	This is an option that allows to stop a step-by-step investment within a project if market conditions turn unfavorable. Such an option is particularly valuable in R&D.	Roberts and Weitzman (1981) [19]; Majd and Pindyck (1987); Carr (1988); Trigeorgis (1993); Grenadier (1996)
Multiple interacting options	Combinations of RO.	Trigeorgis (1991, 1993, 1993); Childs, Ott, and Triantis (1998) [20].

The valuation of investment projects with strategic and operating options, as shown in Figure 1, started in 1977 by Stewart C. Myers. Since 1977, many articles have been published that deal with the valuation of real options [6]. Two main avenues of real options valuation can be distinguished :

- **Analytical methods:** approximate analytical solutions and closed form solutions, including the Schwartz-Moon model.
- **Numerical methods:** approximation of the partial differential equation that describes the option and approximation of the underlying stochastic process of the real option (Schulmerich, 2010) [4].

Figure 1 illustrates this valuation methods, and represents them respectably according to their types. The analytical solutions have the advantage of being accurate, fast and easy to implement for anyone who has basic computer skills. However, they are very difficult to explain to investors because they use techniques of stochastic calculus and mathematical fairly extensive. Moreover, these methods are so specific that they only apply to a small portion of the problems and assumptions are numerous. They are very flexible but require a fairly high level of calculation to be successful (Chance & Peterson, 2002) [3].

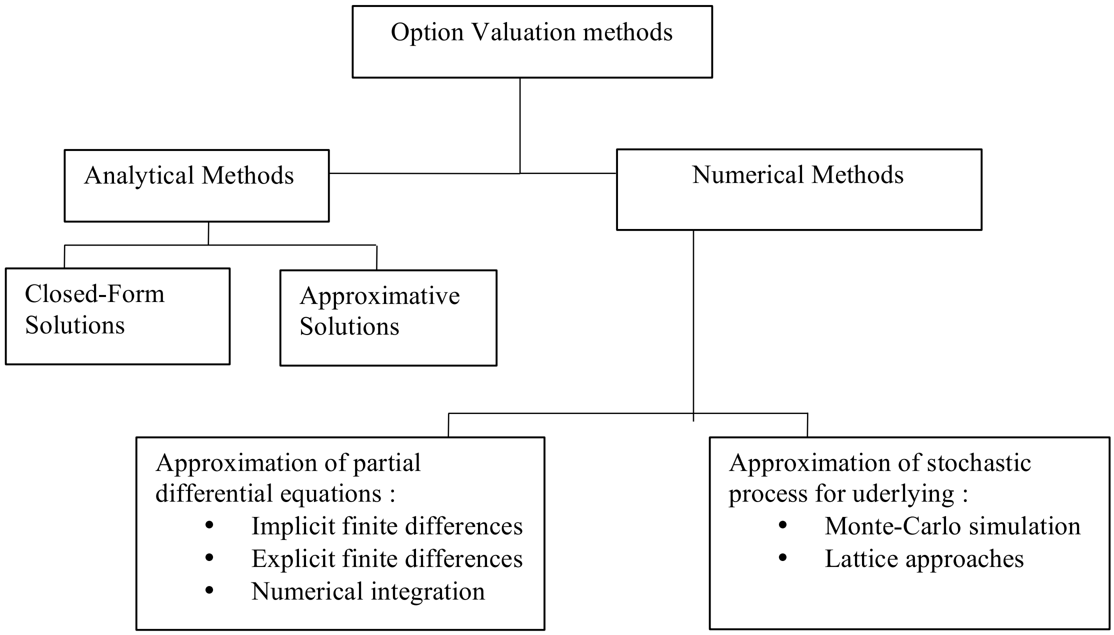

Figure 1. Real Options valuation methods (Hommel & Lehmann, 2001) [21]

The basic idea of real options valuation is to consider that the value of an investment extends beyond its value as measured by traditional discounted cash flows or net present value. In other words, the value of a project is supplemented by the value of its options. Because the options are considered strategic decisions, the revised or supplemented NPV is referred to as the strategic NPV. Consider an investment opportunity that has one option associated with it. The strategic NPV is the sum of the traditional NPV, which we call the static NPV, and the value added of the option analysis (Chance & Peterson, 2002) [3].
Unlike the traditional approach to investment choices, real options actually lead to a more adequate development project that the NPV because they take into account the value of managerial flexibility and the uncertainty in the study of investment decisions.

The approach by Real Options must not sweep the traditional methods based on discounted cash flows. It should only be considered a complementary tool to strengthen other valuation techniques. One source of difficulty in applying real options valuation is the use of option's pricing models that make assumptions that may or may not be appropriate in the case of real options. These pricing models are difficult to learn and to explain to managers who don't have a solid knowledge of mathematics and financial engineering (Chance & Peterson, 2002) [3].

3. A Real Options Approach for assessing an investment profitability in uncertain environment

In this section, we will begin with a comparative analysis of the most used methods, then we will put together general approach for the measurement of the profitability of an investment project in uncertain environment.

3.1 Comparative analysis of profitability measures

Traditional valuation methods, such as NPV, can be modified using sensitivity, simulation, and decision tree analysis to incorporate some managerial flexibility but easily become too complex or unwieldy.

Sensitivity analysis provides a way of looking at the effects on a project's value when one factor is allowed to vary, whereas simulation analysis provides a way of looking at valuation with more than one factor varying randomly (Chance & Peterson, 2002) [3].
Although both methods permit some experimentation with changes in factors, they do not fully capture the flexibility that options inherent in an investment project may offer. Therefore, sticking to NPV, which does not tell the potential of a new technology, may obstruct firm's technology competitiveness development.
Unlike NPV, decision trees focus on modeling various kinds of flexibilities during a life span of a technology project development. It reflects synergies that NPV misses (Wang & Halal,2010) [5]. Moreover, since decision tree models reality with no arbitrage assumption, which is necessary in option pricing models, it can be applied in complete or incomplete markets. Therefore, decision tree modeling provides an alternative to resolve the fundamental problem in real option pricing (Wang & Halal,2010) [5]. And although a decision tree can provide an organized mapping of flexibility options, it uses a single discount rate and fails to capture the true value of these options (Chance & Peterson, 2002) [3].
In contrast to the decision tree's approach, option valuation does not require knowledge of the discount rate that reflects risk or knowledge of the actual probabilities of the outcomes. Although option valuation imposes other demands, those demands are far less onerous.
Many researchers suggested integration of Real Options and NPV for project valuation. According to (MacMillan, 2006) [22], the combination fixes the flaws of NPV analysis in practice (Wang & Halal,2010) [5]. (Trigeorgis, 1993) [12] even quantified this approach by NPV of the real asset investment equals the NPV of estimated cash flows plus the option values.
Those firms able to develop methodologies for evaluating and pursuing technology investments that are rich in opportunity, while controlling risk, will inevitably develop newer technologies than their more timid competitors. By technologically outpacing their peers, these firms will be rewarded with breakthroughs that in turn bring investor recognition in the form of higher market valuations (MacMillan, 2006) [22].

3.2 Proposed general approach for the measurement of the profitability of an investment project in uncertain environment

The following process explains the main steps of the analysis of the uncertainty's sources of an investment project, and highlights an overall estimation of the project's profitability:

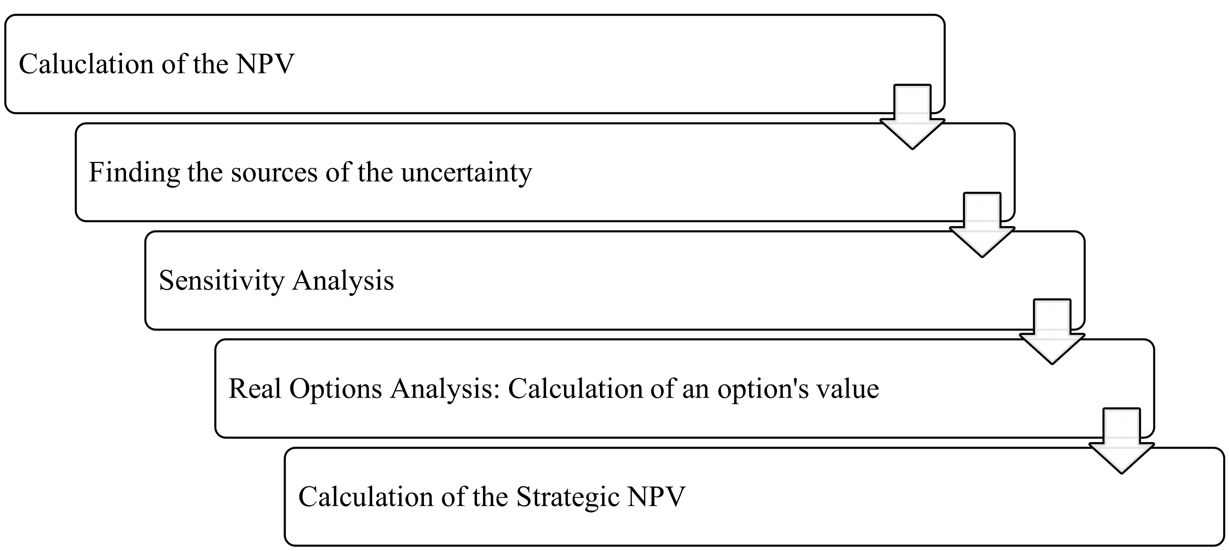

Figure 2. Proposed approach for the measurement of the profitability of an investment project in an uncertain environment.

This process shows that, in addition of the classic calculations of the project's NPV, the determination of the sources of uncertainty is fundamental in an uncertain environment. It can be done by assembling all the criteria capable of influencing the project's durability.
Running a sensitivity analysis helps clarifying the uncertainty, and enhances the understanding of the project's particularities. It also shows how each parameter influences the project's profitability, by simulations while varying parameters and seeing their effect on the NPV.
Although the sensitivity analysis gave a sense of active management of the uncertainties, it's still not able to fully capture the proper value that the flexibility to respond properly to the future market changes.
Hence, the real options analysis tends to propose a multiple types of options, capable of completing the NPV's value and to upgrading the cash flows calculations by including their volatilities. After choosing an option, calculating its value and comparing it with the NPV's value, the decisions-makers will be able to knowing if the project is profitable or not; as it's the case for example for the Abandonment Option: if the option's value is higher than the NPV's value, it means that the abandonment of the project is advisable.
To fully understand the added value of real options, we calculate the value of the strategic NPV that equals the option's value plus the classic NPV value.
Real options are a way of valuing investment projects, which involve irreversible investment decisions subject to uncertainty. Whereas the NPV analysis is based on fixed estimates of costs and revenues, and a predetermined development scenario, real options focus on project flexibility (Galli & Armstrong, 1997) [13]. In many industries, information that will become available in the future or that can be acquired, can add considerable value to projects, and bring change to the whole project's profitability measurements.

4. Conclusion

This paper presents a clear overview of the different analytical methods used to identify a project's profitability. This overview is followed by an assimilation and a comparative analysis between the most common financial methods (NPV, DT, RO), used by managers to determine a project's characteristics. In effect, the flexibility provided by the option to discontinue the project has value that should be considered. The difference between Net Present Value and the Real Options approach is that in conventional NPV proposals the project sponsors implicitly assume that once the project starts all investment steps will automatically be carried out. In fact, after any of many investment steps, projects can be stopped, put on hold, redirected, or postponed. The flexibility to stop, postpone, redirect, or put on hold further investment creates the option value (MacMillan, 2006) [22]. This analysis highlights the importance of incorporating flexibility and adding options in order to be able to seize capital investment opportunities, modify it strategically depending on market changes and benefit from a proactive project management. The proposed general approach, in this paper, for the measurement of the profitability of an investment project can help decisions-makers selecting promising projects and deal with uncertainty and risks properly, with hope to capture the full value of flexibility to respond to future modifications. This work puts forward the theory of real options but in no way denigrates traditional methods like the NPV, which remains a basic tool of financial analysis that can be completed and improved by incorporating the flexibility and reactivity of the real options.

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Biography

Jihane Gharib is a Moroccan engineer who graduated for Mohamadia School of Engineers (EMI) in 2013, is passionate about Financial Analysis and Risk Management, and is now a PhD student in the same school; working on the Analysis and the Quantification of Financial Risks in the Investment Project field. She worked also as a project manager and a financial analysist in a construction company before deciding to fully concentrate on her thesis and researches.

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