Evaluation uncertain investment by Monte Carlo Simulation using Crystal Ball Case Study for a project of ANSEJ (Cyber Café)

Mr. Refafa Abdelaziz, Dr. Benhmida Mohamed, Dr. Ouraghi Sid Ahmed

Abstract— **This research Addresses a thorny issue and perpetually renew, Evaluation of investment projects under uncertainty, theoretical elements response Are available from a discursive reading of the relevant literature, We proposes to study this question for the case of a small Algerian company when we are trying to evaluate a Cyber Café through a fairly robust method namely the Monte Carlo simulation, The results show the great capacity of these methods, Including Monte Carlo simulation to provide relevant information to build a near-optimal decisions in an uncertain future.**

I. INTRODUCTION

The issue of financial evaluation of investment projects has become a major concern and one of the essential steps for project success, thus the failures recorded in the financial evaluation of certain investments and the consequences resulting sometimes hinder the realization and implementation of other projects. As a result, financial managers are increasingly brought to question the validity of the method used, the shortcomings of traditional assessments of investment projects methods, decision criteria used and the introduction of new models that meet the assessment requirements for investment projects[1].

As well, the more probabilistic financial models are based on extensions of the traditional criterion of decision of the NPV. For this, herein, we propose a financial assessment based on the application of NPV and a Monte Carlo simulation model. To do this we consider a Cyber Café project, and it's not a coincidence, the project is well chosen to provide much more value to our work, This is because it should be known that according to officials of the national support for youth employment Agency (Ansej) of the State of Saida, The majority of requests concerning the "rolling", and it mean computing and Cyber Café, And because this projects benefit many tax advantages that the VAT exemption, 5% reduction in tax taxes on imported equipment, exemption of taxes imposed tax on micro-enterprises, even to the full income tax exemption on corporate income. Like any scientific approach, lighting and cast may raise as many questions as provide answers.

What are the best ways to evaluate investment projects in uncertainty?

Investment Definition:

Investment is the purchase of machinery and means of production (Buildings and equipment) Made by an economic agent (business, government, household) with the aim of maintaining or developing technical capital it has[2].

The level of investment in the global economy is determined by gross fixed capital formation (GFCF). Business investment refers to investment in fixed capital made by companies that are genuinely intended to produce other goods; this excludes housing investment (realized by households) and expenses of buildings (which are not immediately productive)[3].

Criteria of Investment choice

Criteria of Investment choice correspond to a set of financial tools of decision aid to provide managers with the means to evaluate and compare different competing investment projects[4]. There are two types of criteria: Temporal criteria (payback), and economic criteria (net present value, profitability index and internal rate of return) that we will present below:

II. ECONOMIC CRITERIA

These are criteria that measures the profitability of the project, the major criterion of this type is the net present value, on which calculation the other criteria of this type namely the profitability index and internal rate of return

A. The Net Present Value (NPV):

The Net Present Value (NPV) is a discounted cash flow representing the further enrichment of an investment over the minimum required by providers of capital[5], NPV is the difference between the current value of the resources and the present value of the expenditure that is

[1.1]

Manuscript received May 23, 2015

Mr. Refafa Abdelaziz, Teaching assistant , Faculty of economic, commerce and Management science, Dr Moulay Tahar University of Saida – Algeria

Dr. Benhmida Mohamed, Lecturer , Faculty of economic, commerce and Management science, Dr Moulay Tahar University of Saida – Algeria

Dr. Ouraghi Sid Ahmed, Lecturer, Faculty of Social Sciences, University of Tlemcen, Algeria

[1] Application d'un modèle de simulation et d'analyse de sensibilité à l'évaluation d'un projet de numérisation, El Ayadi Mohammed Alaeddine, Mars 2008. P1

[2] G. Abraham et G Caire, Dictionnaire d'économie, 2eme éd. Dalloz, Paris, 2002, P236

[3] N. POPIOLEK, Guide du choix de l'investissement, éd. D'organisation, Paris, 2006.PP.2-3

[4] http://archives.reseaucerta.org/glossaire/c/chvinv2.htm

[5] http://fr.wikipedia.org/wiki/Valeur_actuelle_nette

$$NPV = -I + \sum_{j=1}^{n} CF_j (1+t)^{-j} + VR(1+t)^{-n}$$

With: **I**: invested capital, **CF**: cash flow, **t** the discount rate, **VR**: the residual value (value of end of the period, **n**: the project life span

The net present value is the major criterion adopted to assess projects, however, it must be emphasized that it does not allow us to compare between two projects lifespan and various invested capital (it will provide misleading results)

In the first case: unequal lifespan between projects the way forward is as follows:

First, we specified the least common multiple between the two lifespan

We spread Both projects (or more) on this new period, we assume that if we want to renew each project on another period (corresponding to the initial period for each project) we will have the same expenses and so also the same NPV we update all in the time 0 and retained with the highest NPV and ensure it have the same initial capital

In the second case: inequality of initial capital, we move to another criterion (the profitability index) that has more credibility in this case

B. Profitability Index (PI):

While the NPV measure the benefit, (return) Absolute may be made to an investment project, The IP measures the relative advantage, that is to say, the generated profitability of 1 monetary unit invested. It its calculation as follows[6]:

$$IP = \frac{RPV}{CPV} = \frac{\sum_{j=}^{n} CF_j (1+t)^{-j} + VR(1+t)^{-n}}{I}$$

RPV: revenues present value (the flow of cash and residual value)

CPV: costs present value (usually the capital invested)

The discount rate is the same that used for the NPV.

C. Internal Rate of Return (IRR) :

The net present value of a project decreases gradually as the discount rate rises by a decreasing curve, depending on the discount rate.

The IRR is the rate t for which there is equivalence between the invested capital and cash flows generated by the project. Alternatively, it is rate that cancels the NPV Either:

$$-I + \sum_{j=1}^{n} CF_j (1+IRR)^{-j} = 0$$

We assume that the VR = 0

To determine the TIR must use either the mathematical resolution be a linear interpolation we will calculate the NPV for this project several discount rates. We will use the smallest positive NPV and the largest negative NPV (therefore the smallest in absolute value). We will consider the curve of Net present values between these two points as a straight, and estimate the point where this line intersects the abscissa of the curve, the IRR is calculated as follows

$$IRR = p + (q-p)\frac{NPV_p}{|NPV_q - NPV_p|}$$

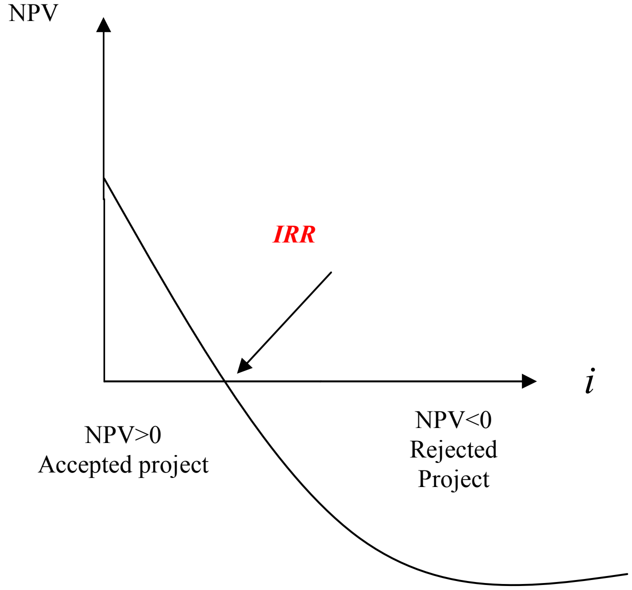

Figure 1: the relation *between the NPV and the IRR*

The NPV is the reference criterion to compare projects and that the IRR is not a relevant criterion for project selection, it just lets you know if the projects are profitable (comparing the IRR of each project and the capital discount rate)[7].

In the choice between two exclusive investments, it is not always wise to choose the one where the IRR is higher.

Indeed, we may found in conflicting situations according to the criteria of NPV and IRR

III. Temporal criteria: Capital Investment Payback Period (PP)

This method is based more on liquidity and in terms of profitability, According to this criterion, between two competing projects; we prefer the one whose investment recovery period is shorter, because it poses less risk to the business. This method is commonly used. In general, now, and out strategic project.

The method of PP (Payback Period) serves both criteria of rejection and selection criteria. As a rejection criterion, since any project payback is higher than the standard set by the company was rejected. As a selection criterion, as between two competing projects, we choose the one with the shortest payback time

Evaluation criteria for uncertain Investment Projects:

In a decision problem under uncertainty we assume that the consequences of our actions depend on the occurrence of various events "Nature's statements" - Nature is supposed to decide what is not under our control. We Assume the Nature "indolent": It systematically seeks to neither our benefit nor our disadvantage.

[6] Nathalie Gardès, Cours de Gestion financière, Chapitre 2 La décision d'investissement, P9, 11

[7] http://fr.wikipedia.org/wiki/Taux_de_rentabilit%C3%A9_interne

The node of such a decision problem lies in the fact that we must choose an action before the acquisition of the decision of Nature[8].

Solving problems related to investments under conditions of uncertainty, including evaluation of investment projects in a world of uncertainty and risk and a possibility of applying different methods and techniques, the best-known are:

- the sensitivity analysis
- The scenario method
- Game theory and the theory of decision

Since the first two methods are the subject of the next chapter, we spent in the following development criteria different from game theory in the evaluation and the selection of investment.

3.1 The sensitivity analysis :

This technique is the most used in the selection of investment with risk and uncertain due to its simplicity and ease of use, it provides the investor large amounts of data and information, it measures the impact of changes in determinant variables of the project (lifetime, initial capital ...) on the final result (net present value or internal rate of return).

3.2 The scenario method :

- **Simulation Definition:**

The simulation is to build a model of a system, to conduct experiments on it, and interpret observations in order to make a decision. It allow to understand the dynamic operation of the system, Compare configurations in order to improve overall performance, It also allows to determine the validity of a model that makes sense, digital, statistics, ... If we simplify the system considered sufficient, under certain assumptions, we can have the equations that allow us to obtain the desired performance. In other words, we do not use simulation until last resort[9]. Anyway, it is often dangerous, expensive and often impossible to do experiment with real systems (particularly true in the industry). The simulation prevent an analytical solution because it does not provide exact answer. It is useful for the study of complex systems[10].

- **Monte Carlo simulation:**

Monte Carlo simulation is a probabilistic statistical method based on strengthening the probability distributions of the inputs and outputs of investment projects, which are more sensitive to risk and uncertainty, this method combines the sensitivity analysis and probability distributions.

- **The decision tree:**

The decision tree is a graphical method to analyze decisions with risk, Models where the probabilities associated with different states of nature are specified. To be more specific, the decision trees has been developed for problems involving a sequence of decisions and successive events. The decision tree is usually represented as decisions or successive events represented chronologically from left to right[11].

[8] Denis Bouysso,u Preference Modelling and Multiple Criteria Decision Aid. P1

[9] Yadolah Dodge. Premiers pas en simulation, Springer-Verlag France, 2008

[10] Jean-Louis Boimond, Simulation systèmes de production réseaux de pétri P2

[11] https://www.tns-ilres.com/cms/Home/WikiStat/Arbre-de-decision

• The nodes that represent decisions are usually represented by squares and a branch following a decision will be associated with each possible decision.

• The nodes that represent events are usually represented by circles and a branch following an event associated with each possible configuration.

The shape of the decision tree

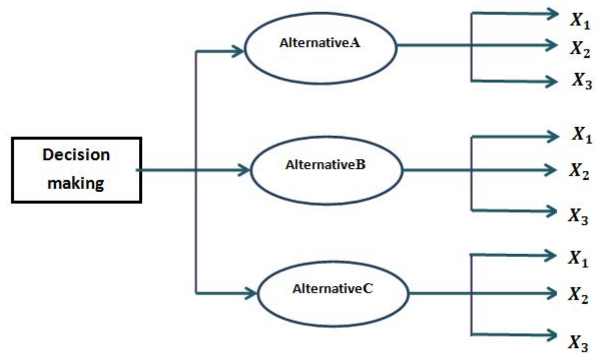

Figure 2: The decision tree

3.3 The Game theory

Game theory is the mathematical discipline that studies situations where the fate of each participant depends not only on the decisions it makes, but also on the decisions taken by other participants. Consequently, the choice "optimal" for a member generally depends on what others are doing. For investment-related issues the second player is nature. A very large number of decision criteria were formulated: We will simply quote the most significant criteria[12],

- the criterion Laplace-Bayes
- criterion of Wald or Maximin
- the criterion of Savage or Minimax Regret
- Hurwicz criterion
- Max Max criterion

- **Monte Carlo simulation:**

The Monte Carlo simulation approach allows to model as closely the behavior of the systems studied but its effectiveness is even greater than the relevant events are more frequent. This therefore gives rather well with problems related to availability.

Therefore, simulation and analytical approaches are not interchangeable. They are complementary and each is well adapted to particular types of problems. However, with the increasing power of computers, security issues are becoming more accessible to the simulation.

We also need to break down the presupposition that says that the Monte Carlo simulation is imprecise compared to the analytical approach, which itself would be accurate. As we will see below, the Monte Carlo simulation always delivers the confidence interval of the results. This is rarely the case of analytical methods for which it is often difficult, if not impossible, to measure the impact of the approximations performed to get a result.

- **Definition:**

The Monte Carlo method is actually digital, The Monte Carlo method is actually digital, present non-deterministic

[12] Jacques-Fran¸cois Thisse, théorie des jeux : une introduction, P2

algorithms for solving deterministic problems using random selections to perform the calculation of a deterministic quantity, represent non-deterministic algorithms for solving deterministic problems using random selections to perform the calculation of a deterministic quantity, these curious

Step 1	by MC simulation, we generate randomly Xi achievements: X1, X2, ..., Xn.
step 2	Each of these accomplishments gives value to the NPV (x).
step 3	The estimate of the NPV that results from the simulation is:: $E_{(NPV)}=1/n\sum_{t-1}^{n} NPV_{(xi)}$
step 4	we can evaluate the accuracy of this estimated by calculating $\hat{s}$ ((Standard deviation): $\hat{s} = 1/\sqrt{n-1}\sqrt{\sum_{i=1}^{n}[NPV_{(xi)} - E_{(NPV)}]^2}$

methods provide a rich application of a law called large numbers. However, these approaches tend to follow a particular pattern[13]:

Define a domain of possible inputs.

Generate random entries in the domain, and run a deterministic calculation on them.

Aggregate the results of the various calculations in the final result.

For example, the value of π can be approximated using a Monte Carlo method. Draw a rectangle on the ground, and then insert a circle in it. Then disperse some small objects (for example, rice grains or sand) especially the rectangle. If the objects are uniformly dispersed, then the proportion of an object in a circle against the objects in the box should be approximately π/4, which is the ratio of the area of the circle than the rectangle. In addition, if we count the number of objects in a circle, multiply by four, and divide by the number of objects in the place, we get an approximation to π. The common properties of Monte Carlo methods are: the confidence of the calculation in good random numbers, and it slow convergence to a better approximation as more data points are collected

- **Principle:**

The principle of the Monte Carlo simulation is simple: it comes to replace the analytical calculation of statistical calculation by performing a number of stories of the studied system. This is not unlike with shaking down nuts: Through simulation of random numbers, we shake the system in all directions and as the ripest nuts fall first, the events of highest probability appear first[14].

Figure 3: Principle of Monte Carlo simulation

[13] Olivier Mgbra, https://www.youtube.com/watch?v=Re-osEgL3OY: Méthodes Monte Carlo/ petite introduction.

[14] Jean-Pierre SIGNORET, Analyse des risques des systèmes dynamiques : réseaux de Petri - Principes. 2008, http://www.techniques-ingenieur.fr/

The Monte Carlo simulation is auto-approximate. Unlike the analytical approach where long mathematical demonstrations may be necessary to legitimize approximations,

In Monte Carlo simulation, only important events are manifested and significant events are eliminated themselves because it does not happen simply or very rarely.

The assignment of numerical values to random variables - scores - depending on the game play [15] .

Each realization of statistical process carries the name of history and accomplishment of many of them it brings together samples that can then be processed by conventional statistical techniques to derive the desired results.

Calculation of the Van we Consider only variable (Xi):

Table 1: Calculate E (NPV) by Monte Carlo simulation

That is to say, when n → ∞, the distribution of the NPV tends to a normal distribution.

The NPV of the estimator confidence interval is therefore:

$$E(NPV) \pm \alpha_c\, \hat{s}/\sqrt{n-1}$$

Where α_c is the critical value.

In the opposite case where we have several uncertain factors, we apply an alternative approach that can be summed up step by step, as showing in the following figure:

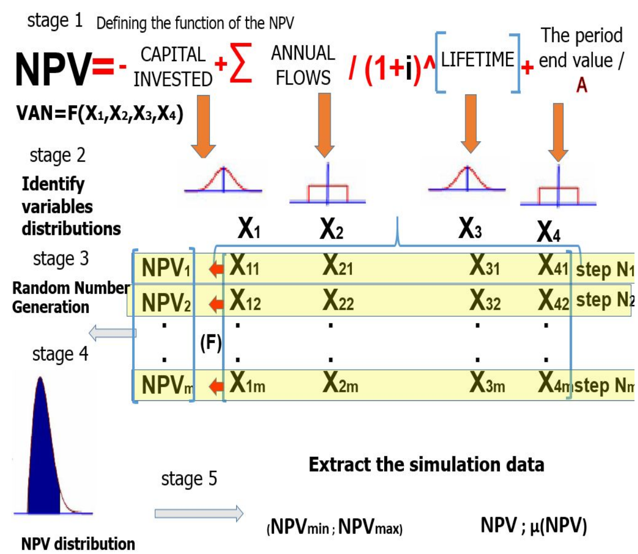

Figure 4: Different stages of the Monte Carlo method

the Monte Carlo simulation techniques use the strong law of large numbers to estimate the required value NPV, which is determined as a function of several variables NPV F (Xi1, Xi2, Xi3, Xi4), (. If the curves Xi = {Xi, o≤t≤T}, 1≤i≤N, represent N trajectory independent and identically distributed

$$E(NPV) = 1/N \sum F(X1, X2, X3, X4) \xrightarrow{\text{converges}} NPV$$

The basic principle of Monte Carlo methods is to generate N trajectory on each factor or variable NPV, and considering E (NPV) as an estimator that converges to the NPV parameter of interest.

[15] Jean-Pierre SIGNORET, Analyse des risques des systèmes dynamiques : réseaux de Petri - Principes. 2008, http://www.techniques-ingenieur.fr/

The central limit theorem allows having an idea of the law carried approximation that converges to a Gaussian distribution:

$$F\,(NPV) \xrightarrow{\text{law}} N\,(0,1)$$

The determination of the number N of simulation required to obtain a satisfactory estimate of the NPV is one of the problems is facing the practitioner. According to the central limit theorem, whenever the variance V of F (NPV) is higher the number of simulations needed to obtain an accurate estimator is important[16].

The method; Monte Carlo simulation is simple to implement using many software that have functions that generate random numbers of any laws.

IV. Application of Monte Carlo simulation

Introduction:

To refine our decision, we propose in this Work to apply the Monte Carlo simulation method, with a Cyber Café project.

Statement of the project:

The project we propose to evaluate under conditions of uncertainty and risk, is of Cyber Café, the choice of this latter is explained by the fact that investment in communication service area (whether in the state of Saida or other) arouses great interest, in fact according to the National Agency in support youth employment (Ansej) of the state of Saida.

The data for this type of investment are recorded below in the Excel sheet:

The data presentation

	A	B	C	D	E	F	G	H	I	J	K
1	Capital Investis	600 000							RESULTAT: VALEUR ACTUELE NETTE		
2	Client/jour	8			Frais fixes		3 200		VAN/10ans	117 308	
3	Jour/Ans	310			Amortissement		60 000				
4	Heur/Client	1			TVA		17%				
5	Prix/Heur	50			Taux D'Actu		10%				
6	Durée de vie	10			valleur fin periode		100 000				
7											
8	Année	1	2	3	4	5	6	7	8	9	10
9	Jour/Ans	310	310	310	310	310	310	310	310	310	310
10	Client/jour	8	8	8	8	8	8	8	8	8	8
11	Heur/Client	1	1	1	1	1	1	1	1	1	1
12	Heur réalisée/ans	2 480	2 480	2 480	2 480	2 480	2 480	2 480	2 480	2 480	2 480
13	Prix/Heur	50	50	50	50	50	50	50	50	50	50
14	Recettes	124 000	124 000	124 000	124 000	124 000	124 000	124 000	124 000	124 000	124 000
15	Frais fixes	3 200	3 200	3 200	3 200	3 200	3 200	3 200	3 200	3 200	3 200
16	Amortissements	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000
17	Bénéfice sans impots	60 800	60 800	60 800	60 800	60 800	60 800	60 800	60 800	60 800	60 800
18	Impôts	10 336	10 336	10 336	10 336	10 336	10 336	10 336	10 336	10 336	10 336
19	Bénéfice	50 464	50 464	50 464	50 464	50 464	50 464	50 464	50 464	50 464	50 464
20	Cash flow	110 464	110 464	110 464	110 464	110 464	110 464	110 464	110 464	110 464	110 464
21	Fact.actu.	0,909	0,826	0,751	0,683	0,621	0,564	0,513	0,467	0,424	0,386

Required rate of return on the project:

For our case, it is not enough that the project generates wealth and that its profitability is positive: the remuneration is that profitability should be high enough given the risks associated with the project and its implementation. The more risks are important, the higher the internal return of the project must be high compensation (each individual is assumed risk-averse: he disagree to take the risk only if it is sufficiently well paid). Our project must be assessed in the light of a minimum net present value required higher, that we need of course to determine.

To do so we will consider an investment project which is in a safely frame such as savings in the bank with a rate of 7.4% annual earnings: the return on a capital of 600,000 DA will provide a net present value of 444 000 DA, in 10 years that we consider an expected minimum value,

Therefore, the car rental project must generate an NPV greater than 444,000 DA, to be accepted.

V. Simulation project with the method of Monte Carlo

The best way to build a good Monte Carlo simulation model is to follow the same steps already defined in the theoretical part;

5.1 Creating a spreadsheet:

After preliminary data estimated in the previous chapter, and creates a complete Excel sheet containing the estimated data and especially the equation of the clear net present value we can move to the second stage:

5.2 Definition of variable parameters and their probability distributions:

5. 2.1. Definition of Variable Parameters:

The definition of each variable parameters always depends on the general environment of the project, as we take the example of a (Cyber Café) we assume to have two uncertain parameters, including clients access per day (C/D) and each client connection time by hour unit (H/C).

- **Definition of Distribution of Each variable:**

To define the distribution of the input parameters considered as variables we must take experts opinion in statistics and probability:

In our case we chose:

For (C/D) a normal distribution with mean μ = 8 with (C/D) min = 4, (C/D) max = 12;

For (H/C) triangular distribution with mean μ = 1 hour (H/C) min = 0.5 (H/C) max = 1.5

5.3 Generating random numbers:

To generate random numbers from probability distributions already defined, we must use a good generator, this step is the most important in the Monte Carlo simulation, used the software (Crystal Ball Version 11.12).

After defining the distributions of the input values in the software, we start by determining the number of iterations n which must be sufficiently large, we take n = 1,000,000, and starts the random number generation;

The choice of the adequate number of iterations is through a rather simple, we begin to enter the number 1000 for example, and we observe the evolution of the parameter of interest (the NPV for our case) we increased the number of iterations while looking at as the evolution of this parameter, while this evolution begins to be negligible, we fix the number of iterations to the last digit retained.

[16] Méthodes de Monte Carlo appliquées à la Finance – Nicolas baud et Vincent porte. Jean-Guy Degos Amal Abou Fayad. e-theque 2003

Concerning our study the evolution became negligible after the number of iterations 1,000,000

5.4 Determining the distribution of the NPV:

After the software terminates the generation of random numbers, There will be a series of values of NPV resulting then we must build a probabilistic distribution, as illustrated in the following graph

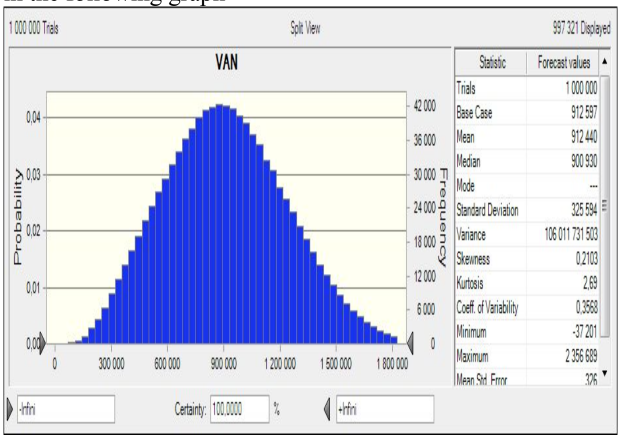

Figure 5: The Distribution of Van According to Crystal Ball

5.5 Extracting the simulation results:

The last step is to extract simulation results

- The mean of the distribution of the NPV:

This is the value searched for in this study because it is a very close approximation of the actual NPV:

μ (NPV) = 912 440

- The standard deviation σ It represent the square root of the variance of this distribution " absolute risk'

σ=325 594

NPV values 1,000,000 with their counterparts of the variable parameters, Plus statistical values of the distribution of the NPV:

Statistics	NPV		
Trials	1000000		
Base Case	912 597		
Mean	912 440		
Median	900 930		
Mode	---		
Standard Deviation	325 594		
Variance	106 011 731 503		
Skewness	0,02103		
Kurtosis	2,69		
Coeff. of Variability	0,3568		
Minimum	-37 201		
Maximum	2 356 689	12	1,50
Range Width	2 393 889	8	1,00
Mean Std. Error	326	0	0,00

Table 2: The Results of the Definitive Simulation

By visualizing the table ensures that the generated NPV responds to the basic hypothesis of the Monte Carlo simulation, which states that the parameter of interest follows a normal distribution well, the coefficient relating to normality are 3 for kurtosis and nearly 0 for skewness, Which corresponds to a Gaussian motion (normal distribution), so we judge that it's a good estimate generated by the Monte Carlo simulation.

VI. RESULT ANALYSIS AND DECISION-MAKING

After observing **Table 2** and **Figure 5** the average of the net present value of the project is 912440 DA Which gives a fairly large positive value to cover the standard deviation of 325594 DA and a maximum NPV of 2,356,689 DA and minimum - 37 201DA a negative value that can be neglected compared to the average and the maximum expected

The Monte Carlo simulation is interested in the average distribution which in our case is worth more than 444 000 DA –the required minimum- so our decision is to accept the car rental project.

CONCLUSION

The Monte Carlo method is a necessary tool, to be used in the conception calculations uncertainties, the implementation of the Monte Carlo method presented in this work leads to use software like (Crystal Ball). This software allows a great flexibility and allows working with samples of large size (several million values). Using the flexibility of the Windows interface while maintaining the power calculating of the Monte Carlo method.

In order to address the issue, which constitutes the subject of interest in this research, which is the evaluation of a project under risk and uncertain environment, we discussed numerous of theoretical and technical aspects of the principle of evaluation of investment projects of the Monte Carlo simulation. We first tried to understand theoretically the principle of these tools, then we approached concretely these two methods by applying them to evaluate a car rental project after the National Support Agency youth employment (Ansej), The advantage of this choice is that according to the same agency the majority of requests concerning the " Traded" that is to say, transport and car rental. This is so that our study must put a tangible scientific interest.

As project acceptance criterion we used the profitability of a project without a risk which is Thrift, where this last generates a net present value of 444 000 DA over five years, the method has provided a very probable approximation of the actual NPV.

BIBLIOGRAPHIE

[1] Application d'un modèle de simulation et d'analyse de sensibilité à l'évaluation d'un projet de numérisation, El Ayadi Mohammed Alaeddine, Mars 2008. P1

[2] G. Abraham et G Caire, Dictionnaire d'économie, 2eme éd. Dalloz, Paris, 2002, P236

[3] N. POPIOLEK, Guide du choix de l'investissement, éd. D'organisation, Paris, 2006. PP.2, 3

[4] http://archives.reseaucerta.org/glossaire/c/chvinv2.htm

[5] http://fr.wikipedia.org/wiki/Valeur_actuelle_nette

[6] Nathalie Gardès, Cours de Gestion financière Chap2 La décision d'investissement, PP.9, 11

[7] http://fr.wikipedia.org/wiki/Taux_de_rentabilit%C3%A9_interne

[8] Denis Bouysso,u Preference Modelling and Multiple Criteria Decision Aid. P1

[9] Yadolah Dodge. Premiers pas en simulation, Springer-Verlag France, 2008

[10] Jean-Louis Boimond, Simulation systèmes de production réseaux de pétri P2
[11] https://www.tns-ilres.com/cms/Home/WikiStat/Arbre-de-decision
[12] Jacques-François Thisse, théorie des jeux : une introduction, P2
[13] Olivier Mgbra, https://www.youtube.com/watch?v=Re-osEgL3OY : Méthodes Monte Carlo/ petite introduction.
[14] Jean-Pierre SIGNORET, Analyse des risques des systèmes dynamiques : réseaux de Petri - Principes. 2008, http://www.techniques-ingenieur.fr/
[15] http://www.techniques-ingenieur.fr/
[16] Jean-Pierre SIGNORET, Analyse des risques des systèmes dynamiques : réseaux de Petri - Principes. 2008, http://www.techniques-ingenieur.fr/
[17] Méthodes de Monte Carlo appliquées à la Finance – Nicolas baud et Vincent porte. Jean-Guy Degos Amal Abou Fayad. e-theque 2003
[18] Evaluation financière des projets- Ingénierie de projets et décision d'investissement. Auteur: Robert Houdayer Editeur: Economica 1999
[19] Guide du choix d'investissement Auteur(s) : Nathalie Taverdet-Popiolek Editeur : Editions d'Organisation Groupe Eyrolles, 2006
[20] Finance computationnelle et gestion des risques : Ingénierie financière avec applications Excel (Visual Basic) et Matlab – Presses de l'Université du Québec – 2006 François-Eric Racicot, Raymond Théoret, Christian Calmes, Juan Salazar.
[21] La gestion des risques - 2 édition Dunod, Paris, 2008 Auteur(s): Olivier Hassid
[22] Premiers pas en simulation Yadolah Dodge. Springer-Verlag France, 2008
[23] Introduction aux méthodes numériques Franck Jedrzejewski Springer-Verlag France, Paris 2005
[24] 24.Piloter les risques d'un projet. Groupe Eyrolles, 2009 Henri-Pierre Maders (, Jean-Luc Masselin
[25] Gestion financière 4em édition. BREAL 2007 De Gérard Melyon
[26] ETAT DES FLUX DE TRESORERIE. De Anne Fortin 1998, Presses de l'Université du Québec
[27] Les choix d'investissement. Auteur : Arnaud Thauvron e-theque 2003
[28] Analyser ET maîtriser la situation financière de son entreprise Claude-Annie Duplat. Vuibert 2004
[29] Hasard, nombre aléatoire ET méthode Monte Carlo. Louis Laurencelle - Presses de l'Université du Québec - 2006
[30] Application d'un modele de simulation et d'analyse de sensibilite a l'evaluation d'un projet, memoire presente par Arlette Michelle Edzango Okap, en 2008
[31] 31. Crystal Ball 11.1.2 User Guide - Oracle® Crystal Ball, fusion edition 2010
[32] Hacure A., Jadamus M. and Kocat A. (2001) Risk Analysis in Investment Appraisal Based in Monte Carlo Simulation Technique, the European Physical Journal B, No. 20.
[33] Evaluation de projets d'investissement pétrolier en utilisant la simulation de Monte Carlo - Fateh BELAID and Daniel DE WOLF.