Risk Analysis and Uncertainties in Capital Investment Appraisal: Application of Monte Carlo Simulation

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Abstract

Every business decision involves risk and decision-making has become increasingly more complex today because of uncertainty. Since capital investment is a long-term function, it becomes obvious that the further into the future plans are made the more uncertain are the outcome. It is expected that only top management will be equipped with the management skills to predict the future with some degree of confidence and certainty. One way through which the management can predict the future of the outcome with some degree of confidence and certainty is through Monte Carlo simulation. Monte Carlo simulation is a tool that shows the possible outcome based on certain key characteristics or behaviors of a system using random numbers. The paper has shown that Monte Carlo simulation enables the management predict the outcome of wrong estimates and prepare their minds better about the possible losses that may occur and thus concrete plans can be put in place to minimize the effects of such possible losses if they occur as a result of inaccurate estimates in key variables. The paper concludes that overlooking significant inter-relationships among the projected variables can distort the results of risk analysis and lead to misleading conclusions. The paper recommended that organizations should send their staff on training to upgrade their skills to enable them implement Monte Carlo simulation which will enable management make an informed decision on capital investment decisions.

Introduction

Every business decision involves risk and decision-making has become increasingly more complex today because of uncertainty. Risk arises out of the uncertain conditions under which a firm has to operate its activities. Due to the inability of firms to forecast accurately cash flows of future operations the firms face the risks of operations. The capital investment proposals are not based on perfect forecast of costs and revenues because the assumptions about the future behaviour of costs and revenue may change. Decisions made by management have to be made in advance assuming certain future economic conditions. Thus, management must understand the way risk contributes to outcome of a decision. The best business decisions may not yield the desired results because the uncertain conditions likely to emerge in future can materially alter the fortunes of the company, hence when threats from risk occur it can make a seemingly-successful project fail (Adeleke, 2002: 11).

The top management usually assumes the responsibility for authorizing all capital investments such as purchase of new equipment, introducing a new product line and so on. Capital investment decisions which are strategic in nature require managers to consider a broad range of factors that may be difficult to estimate.

The amount of money involved is usually very large and in most cases the money is borrowed with high interest rate and conditions. Once the decision to invest has been made, the resources of the organisation will be tied-up for a very long period of time and in most cases such monies may be very difficult to recall without huge losses. Since capital investment is a long-term function, it becomes obvious that the further into the future plans are made the more uncertain are the outcome. It is expected that only top management will be equipped with the management skills to predict the future with some degree of confidence and certainty (Okoye, 2011:383).

Linder (2002:304) opines that uncertainties can exist when the outcome of an event is not known for certain, and when dealing with investments whose benefits are expected to extend beyond one year, certainly, there will be some element of risk. The evaluation of risk therefore depends, on managements' ability to identify and understand the nature of uncertainty surrounding the key variables and on the other hand, having the tools and methodology to process its risk implications. Whatever risk appetite an organisation is, it should evaluate the risk associated with its prospective strategies before making important decisions.

According to Bailes, and Nielsen, (2001: 24) one way through which the management can predict the future of the outcome with some degree of confidence and certainty is through Monte Carlo simulation. Monte Carlo simulation is a tool that shows the possible outcome based on certain key characteristics or behaviors of a system using random numbers. Monte Carlo simulation adds the dimension of dynamic analysis to capital budgeting by making it possible build up random scenarios which are consistent with the managements key assumptions about the risk which traditional capital budgeting techniques do not adopt. Thus, the main objective of this paper is to show how quantitative risk analysis can contribute to understanding risk exposure and making better strategic decisions through the use of Monte Carlo simulation in capital investment decisions.

Literature Review

2.1 The Concept of Capital Investment and Capital Investment Appraisal

Capital investment has been given different interpretation

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by different authors at different times, though the concept has been the same. For instance, Lucey (2007:212) describes capital investment as a situation where firms make a current cash outlay for the benefit to be realized in the future. Similarly, Major (1991) and Pandey (2010) describe capital investment as a decision to invest a firm's current fund in the most efficient way in the long term activities, in anticipation of an expected flow of future benefits over a series of years.

Lucey (2007) sees investment appraisal as the evaluation of a conceived plan with a view to making a decision on whether to accept or reject it based on its expected returns on the capital invested. At a particular point it is possible for a firm to be faced with multiple project proposals than a firm is able to handle. Due to the irreversible nature of some projects or the substantial amounts involved, a screening and ranking exercise becomes necessary in order to drop undesirable projects that yield low returns.

Over the years there have been several investment appraisal techniques developed ranging from traditional techniques to sophisticated techniques to aid management in making capital investment decisions. Adeleke (2002); Pandey (2010); and Kurfi (2003) categorize these techniques into discounted cash flow (sophisticated) models and traditional or fundamental models. The traditional techniques (pay back and accounting rate of return), according to Kurfi (2003) do not incorporate the modern concept of time value of money, and hence the name traditional models. While the discounted models (net present value, internal rate of return, and profitability index or benefit-cost ratio), take into cognizance both the overall profitability of projects and also the timing of returns (Brealey and Myers, 2002); in addition the discounted cash flow model is concerned with cash receipts and payments made (or foregone), and considers only relevant cost (Olowe, 1998 and Adeleke, 2002).

2.2 Concept of Risk and Uncertainty

Risk and Uncertainty are concepts that deal with expectations in future. Life begins with risk, and probably there are no human activities that do not involve some amount of risk. Risk can be seen from different perspective. In economics, risk is expressed as an expected value that an event will be accompanied by undesirable consequences. It is measured by both the probability of the event and the seriousness of the consequences. In planning, risk can be seen as what can happen that will cause the project to fall behind schedule or go over cost. During planning, the known-unknowns are risk. In management, risk is the possibility that outcomes will be different from what we expect. It is the effort to manage both the known-unknowns and unknown-unknowns. All these definitions of risk agree on one point and that risk is a future problem that can be avoided or reduced when undertaking an activity (Major, 1995: 31).

Uncertainty on the other hand can be seen as a decision whose outcome is expected to be more than one but the decision maker has no facts about the possible outcomes and therefore cannot assign probability values to them (Okoye 2011:404). Galbraith, (1973) opines that a condition of uncertainty usually exists in capital budgeting because investment decisions, by definition, involve uncertain outcomes that in the long run are important to firm survival and about which complete information is unavailable (Zhu and Weyant, 2003).

According to Pandey (2010:274) generally, risk and uncertainty seem to mean one and the same thing that is they connote actions or events over which one has no control and may occur in future. Technically risk refers to a situation where the probability distribution of the cash flow of an investment proposal is known. On the other hand, if no information on the probability distribution of the cash flow of an investment proposal is known it is referred to as uncertainty.

2.3 Factors that Influence Capital Investment Decisions

According to Okoye (2011:385) there are several factors that influence the capital investment decisions by management such as the management's attitude to risk taking. Some individuals by their nature do not like taking risks. This explains why in some organisations management is reluctant to invest even where funds and potential profitable investment opportunities are available. It can be said that the nature of the individuals that constitute the top management influences the decision to invest on capital projects or not.

Another factor is the availability of alternative investable projects. Where there are many opportunities, management appraises the projects and selects the most profitable or cost saving projects which show some measure of certainty and minimal risk.

The fiscal policy of government is another factor that influences the decision to invest. Government uses certain parameters to encourage or discourage investment in different industries through taxation, liberal loan policies towards some sectors or locality and so on. Such government fiscal policies may propel management to invest their available fund or not.

2.4 Methods of Handling Uncertainty in Capital Investment Decisions

There are different ways of providing for uncertainty associated with critical variables in capital investment decisions. Such variables in capital decisions which involve a high degree of uncertainty include cash flow, economic life of the project and expected minimum rate of return. The ways of providing for uncertainty include * Use of high acceptable minimum discount rate;

* Accepting protects with short discount rate;
* Pessimistic prediction of annual cash inflow;
* Simultaneous comparison of optimistic, pessimistic and best-guess predictions of different variables;
* Sensitivity analysis. (Okoye 2011:405)
* Monte Carlo Simulation

2.5 Monte Carlo Simulation

According to Drury and Tayles, (1996) Monte Carlo analysis was first used during the Second World War to predict movements of submarines. Today it continues to have business, scientific and engineering applications. Monte Carlo is specifically about future risks. Falusi (1983) opines that Monte Carlo simulation is a powerful tool to evaluate the impact of uncertainties on the key variables in a project. Monte Carlo simulation is a method of examining the impact on a strategy of the main risks, including technical, external, competitive and regulatory factors, as they may act simultaneously to modify the result found in a deterministic model. Usually projects are evaluated using a measure of value such as the net present value (NPV) or internal rate of return (IRR) which can be built in a model to show how simulation can be applied to complex and realistic spreadsheet models (Cotton and Schinski, 1999).

2.6 Benefits of Using Monte Carlo in Evaluating Risk In Capital Investment Decisions

Monte Carlo simulation provides a number of benefits to the evaluation of risk in capital investment decisions, which include:

1. Capital investment decisions are uncertain in the future, and statistical approaches are specifically designed to handle such problems. Monte Carlo does all the computations which enables the management to concentrate on the model and the input data (Gropelli and Nikbakht, 2000).
2. Other risk analysis methods such as sensitivity analysis consider each risk at a time and prioritise them, but cannot evaluate the impact of all risks simultaneously. For this reason, Monte Carlo simulation is one of the most powerful technique to evaluate capital projects in order to achieve specific strategic objectives. The only requirement is that the analysis can only be carried out in a spreadsheet such as Microsoft Excel using add-ins softwares such @Risk, ModelRisk and Oracle Crystal Ball (Farragher, Kleiman, and Sahu,1999).

2.7 Application of Monte Carlo Simulations in Capital Investment Appraisal

Assuming the management of a manufacturing outfit intends to invest in a Project worth N10 million which is expected to last for 4 years. It is expected that the project will yield an annual cash flow of N3.6 million. The project's cost of capital is about 10%. (Adapted from Okoye, 2011:406)

In order to determine the viability of the project there are many capital investment appraisal techniques that could be applied. One of the most common investment appraisal techniques used is the Net Present Value (NPV). The basic decision rule for a project appraisal is that the project is accepted if the project has a positive NPV while the project is rejected if the project has a negative NPV. Similarly, when choosing among alternative (mutually exclusive) projects, the decision rule is to select the one with the highest NPV, provided that it is positive.

The NPV of the project is computed with the aid of a spread sheet (MS Excel 2010). The result is presented in the table 1:

Table 1: Result of the Net Present Value using Spread Sheet (MS EXCEL 2010)

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CAPITAL INVESTMENT	N10,000
ECONOMIC USEFUL LIFE	4 YEARS
ANIMAL CASHFLOW	N3600
MINIMUM RATE OF RETURN	10.00%
NPV	N1,412

Source: Researcher's Computation (2012) using MS Excel 2012

The purpose of project appraisal is to establish whether a project is worthwhile in the light of its costs in terms of resource commitments and the project's expected benefits. Based on the computation, the project should be accepted since it would have a positive NPV of N1, 412 million. The management could make wrong decision if they rely on the result without taking into consideration the risk of changes in some of the key variables such as the cost of capital, the economic useful life, the cash inflow and so on.

In practice, companies try to resolve some of the risks in projects by applying sensitivity analysis to the major variables of the projects. The aim is to quantify the impact of changes in the variables of a project on the decision. However, the variables of a project are inter-related, thus the major problem with sensitivity analysis is that it can only show the effect of a single variable on the NPV of the project which may alter the decision and not all the variables simultaneously. Again, sensitivity analysis does not take into consideration the probability distribution of the variables on their likely impact on the NPV.

We do not know the outcome of many future events with certainty. One way to handle the problem is to use a probabilistic model that would describe the situation. This is especially true of financial decisions where we do not know the future cash flows exactly. One way to overcome this uncertainty is to develop a subjective probability distribution about different possible outcomes. With the application of risk analysis and the careful consideration of the risk component of the main variables of a project and their relationship, it may be possible to establish a sound basis on which to evaluate project risk. Risk analysis using the Monte Carlo method is fundamentally not different from scenario analysis. The only difference is that the software builds the scenarios generated in the analysis which enables us see the best scenario, normal

scenario and the worst scenario.
The Monte Carlo simulation was carried out after 100 trials The result from the Monte Carlo simulation is presented below:

Table 2: Statistics from Monte Carlo Simulations

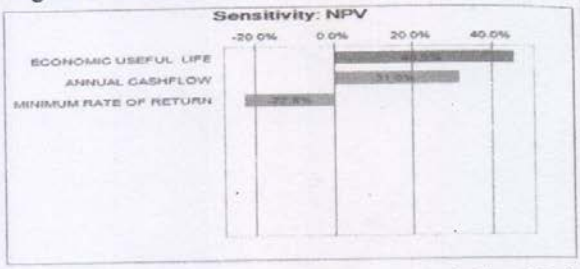
Statistics	Forecast values
Trials	100
Mean	4,078
Coeff. of Variability	0.8577
Minimum	-1,477
Maximum	14,548

Source: *Researcher's Computation (2012) using Oracle Crystal Ball.*

The initial computation showed a positive NPV of N1,412 million after about 100 possible trials, it was observed that the value of the NPV could fall within a negative NPV of N1,477million and a positive NPV of 14, 548million. The average NPV was about N4,078 million (See appendix 1 for the full result of the Monte Carlo Simulation). The coefficient of variation which measures project risk shows the coefficient of variation with a value of 0.85(85%) indicates that the project has a very high risk. The result in *appendix I* shows that the best possible scenario is that the project could have a positive NPV of N14,548 million if the minimum rate of return is about 5.5%, with an annual cash inflow of N4534.53million and an economic useful life of 7 years . The project would not be viable if the minimum rate of return is about 8.71%, with an annual cash inflow of N3003.09 million and an economic useful life of 4 years which will have a negative NPV of N41,000. The worst possible scenario, the project could have a negative NPV of N1,477 million if the minimum rate of return is about 8.46%, with an annual cash inflow of N2747.06 million and an economic useful life of 4 years..

The management can see the possible scenarios in which the project can fail and on the basis of this, management can plan and negotiate with the bank the minimum cost of capital which it can borrow to invest. The management could thus, take tomorrow's decision today with some level of confidence since it can predict the best, worst and mostly likely changes in the variables scenario. If the project after 100 or even 10000 trials the project has a positive NPV it implies that the management should be confident that investment in the project must be viable, since after stress testing the project given all the possible uncertain changes in the variables that project would still be viable.

Figure 1: Tornado Charts



Source: *Researcher's computations (2012) using Oracle Crystal Ball*

The tornado chart above shows the sensitivity of key variables on the NPV of the project. The result shows that the economic useful life and the annual cash flows have a positive impact on the NPV of the project. The strength of relationship between the economic useful life of the project and the NPV is about 45.6% while the strength of relationship between the annual cash flows of the project and the NPV is about 31.6% while the minimum rate of return (cost of capital) has a negative impact on the NPV. The economic useful life of the project is the major driver of the NPV.

2.8 Challenges Of Using Monte Carlo For Risk Analysis in Capital Investment Decision By Firms in Nigeria

i. Most of the members of management may not understand risk analysis or the applications of Monte Carlo simulation in making strategic decisions.
ii. The staff of most firms may not be aware of the availability of the technique either some people at the decision-making level are known to be hostile to new ways of analyzing decisions or they may prefer the intuitive and *ad hoc* approach that has served them well in the past.
iii. The corporate culture may not be friendly to risk analysis. Corporate organisations and their leaders are often not friendly to considering business risk in a careful and objective way. There are many managers who do not want to hear about risk of their plans and strategies. This factor may be caused by the need to consider strategic elements that are not pleasant to discuss. The topic of risk is not very popular with corporate leaders when they are trying to make a decision.

3.0 Summary and Conclusion

Planning for organizational success involves dealing with many kinds of risk. Without risk there would be no challenge in business. Threats, if they materialise, can make a seemingly-successful strategy fail and opportunities, if captured, can enhance management decision favorably. Whether an organisation is risk-averse, risk-seeking or risk-neutral, it should evaluate the risk associated with its prospective strategies before making important decisions. The evaluation of capital investment therefore depends, on the management's ability to identify and understand the nature of uncertainty surrounding the key project variables and on the other hand, having the tools and methodology to process its risk implications on the return of the project. The paper has shown that Monte Carlo simulation enables the management predict the outcome of wrong estimates and prepare their minds better about the possible losses that may occur and thus concrete plans can be put in place to minimize the effect of such possible loss if they occur as a result of inaccurate estimates in key variables. The management can thus make high degree of confidence because the expected losses can be quantified and anticipated losses before they occur. The paper concludes that overlooking significant inter-relationships among the projected variables can distort the results of risk analysis and lead to misleading conclusions. The management should take due care to identify the major correlated variables and to adequately provide for the impact of such correlations in the simulation.

4.0 Recommendation

The management of organizations should be very interested in exploring ways to look at strategic risk in capital investment decisions. Thus we recommend that organizations should send their staff on training and workshops to upgrade their skills to enable them implement Monte Carlo simulation which will enable management make more informed judgement on capital investment decisions.

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APPENDIX I

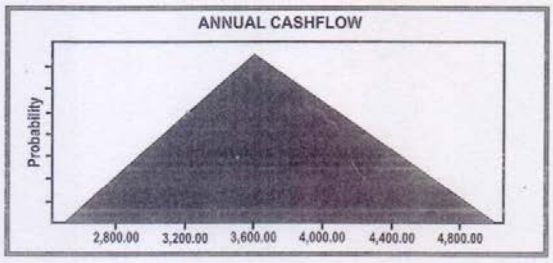
NPV (N'Million)	Annual Cashflow (N'Million)	Economic Useful Life (Years)	Minimum Rate of Return
14,548	4,534.53	7	5.53%
14,295	4,545.57	6	3.07%
11,849	4,474.04	5	2.64%
11,115	4,601.27	6	5.86%
10,723	3,641.19	7	4,46%
10,241	4,021.94	6	5.26%
9,854	3,958.86	6	3.31%
9,696	4,526.41	6	9.73%
9,606	3,632.53	7	7.52%
8,633	4,184.61	5	5.22%
8,455	3,446.72	7	6.22%
8,448	3,677.62	6	6.83%
8,371	4,564.78	6	11.24%
8,177	4,685.33	5	8.60%
8,071	4,474.04	4	2.98%
7,979	3,925.71	5	3.85%
7,505	3,390.43	6	5.38%
7,319	3,729.55	6	9.18%
7,097	3,405.79	6	6.74%
7,003	3,418.95	7	9.09%
6,922	3,459.48	6	5.10%
6,764	4,064.22	6	11.96%
6,752	3,831.22	6	9.89%
6,724	4,561.23	7	18.20%
6,349	3,436.79	8	12,49%
6,255	4,140.33	6	14.61%
6,083	4,087.91	5	11.09%
6,064	3,989.51	4	3.05%
6,015	3,471.01	6	6.64%
5,943	3,966.18	5	7.02%
5,761	3,590.33	5	5.09%
5,694	3,698.00	6	12.13%
5,680	3,757.79	5	6.88%
5,614	3,833.27	6	12.37%
5,244	3,839.51	6	14.94%
5,051	3,545.68	5	7.61%
4,691	4,730.19	4	10.04%
4,656	4,319.94	5	13.96%
4,621	3,786.15	5	6.28%
4,619	3,795.34	5	8.20%
4,421	3,469.75	5	8.78%
4,247	3,846.37	5	10.62%
4,187	3,871.34	5	13.83%
4,035	3,809.55	6	14.58%
3,941	3,203.99	6	10.29%
3,842	4,824.19	4	1215%
3,575	3,476.73	7	16.48%
3,533	3,649.75	5	10.11%
3,517	3,780.02	5	10.52%
3,384	3,498.37	5	7.57%
3,302	2,938.79	5	4.39%
3,290	3,283.49	7	16.26%
3,149	2,910.47	5	4.95%
3,079	3,432.72	5	9.75%
3,018	3,607.43	4	7.38%
2,904	3,533.84	6	15.69%
2.881	4,074.60	4	9.14%
2,855	3,167.40	5	8.77%
2,851	3,413.05	6	13.97%
2,715	3,215.19	5	8.42%
2,629	3,160.81	5	8.44%
2,513	3,369.46	5	11.65%
2,174	3,495.58	5	11.58%
2,164	3,480.00	6	18.59%
2,122	3,856.66	5	18.51%
1,975	3,285.87	4	4.79%
1,966	3,851.79	4	9.99%
1,910	3,122.56	6	15.57%
1,857	3,476.88	4	10.13%
1,719	3,581.64	5	17.46%
1,663	3,997.27	4	11.52%
1,641	4,518.89	3	11.63%
1,591	3,173.13	4	4.18%
1,531	3,295.80	5	12.31%
1,505	3,963.32	4	16.05%
1,480	3,582.49	4	9.89%
1,241	3,463.98	5	15.74%
1,238	3,163,93	5	10.71%
1,230	2,881.66	5	10.30%
1,160	3,998.87	4	12.98%
1,111	3,734.80	4	13.68%
910	3,191.82	4	10.39%
903	2,943.12	5	9.87%
835	2,928.03	5	10.37%
799	3,660.57	4	13.80%
783	3,648.31	4	16.26%
519	2,947.99	5	14.495
470	3,361.56	4	13.29%
369	3,335.67	4	9.76%
348	3,896.57	3	11.32%
-41	3,003.09	4	8.71%
-349	2,667.69	5	12.17%
-385	2,797.24	4	3.99%
-555	3,441.88	4	13.33%
-747	3.153.02	4	16.90%
-787	3,474.02	3	11.83%
-935	3,622.14	3	13.24%
-1,041	2,842.13	4	12.25%
-1,455	3,316.91	4	17.37%
-1.477	2,747.06	4	8.46%

APPENDIX II

Assumption: ANNUAL CASHFLOW

Triangular distribution with parameters

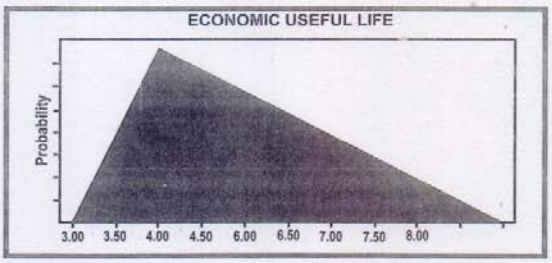
Minimum	2,500.00
Likeliest	3,600.00
Maximum	5,000.00



Assumption: ECONOMIC USEFUL LIFE

Triangular distribution with parameters

Minimum	3.00
Likeliest	4.00
Maximum	8.00



Assumption: ECONOMIC USEFUL LIFE

Triangular distribution with parameters

Minimum	0.01
Likeliest	0.10
Maximum	0.20