The International Journal of Engineering and Science (IJES)
|| Volume || 9 || Issue || 01 || Series II || Pages || PP 30-36| 2020 ||
ISSN (e): 2319-1813 ISSN (p): 23-19-1805

Economic Evaluation of Quarry Operations InOndo State, Nigeria, Using @RISK ForMonte Carlos Simulation

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--**ABSTRACT**--
Mining is a capital intensive business that needs experienced personnel to manage the activities carried out in the mines. For that reason, economic evaluation of aggregate quarries for investment decision is an important evaluation that must be done from time to time in a quarry. Economic evaluation was carried out at two selected quarries in Ondo State using the evaluation methods such as; [Net Present Value(NPV), Internal Rate of Return(IRR) and Profitability Index(PI)] and Monte Carlos simulation using @RISK in this research paper. The data used for this paper are secondary data obtained from the two quarries.The economic analysis indicates that based on the cash flow data obtained from the quarries, the evaluation methods (NPV, IRR and PI) were analyzed using Microsoft excel, the results obtained from the analyses are high, therefore met the decision criterion for each evaluation methods. It shows that Quarry B as the highest NPV of NGN 3,422,702,435.87, Quarry A as the highest IRR of 321% and PI of 14.02329543. An add-in Microsoft excel software known as @RISK was used for the Monte Carlo Simulation to carry out several simulations of 10,000 iterations for the two quarries using the evaluation methods results as the input data for the analysis. The result obtained reflects the probability distribution graphs, curves and sensitivity analysis using the tornado graph to explain each evaluation methods for each quarries. This research reflects a new approach to economic evaluation using a software (@RISK) which is accurate and easy to interpret and how the evaluation methods were well analyzed for investment decisions. It is recommended that quarry companies should use the new approach to analyze their project investments decisions and financial models.

Keywords*: Economic, Evaluation, Simulation, Analyses, Quarry, Investment, Decision*

Date of Submission: 15-01-2020 Date of Acceptance: 31-01-2020

I. INTRODUCTION AND PROBLEM STATEMENT

Economic evaluation is a way of systematically analyzing all the costs and benefits associated with a project and assessing its overall benefits. The analysis can incorporate monetary, quantitative and qualitative factors. Economic evaluation can assist in better quantification of the benefits and a more balanced assessment of the relative merit of options. Evaluation provides vital information to decision makers at various levels within operation (Moselem*et al.*, 2015). The use of economic evaluation is encouraged in all relevant areas of public secor activity including policy proposals, program evaluation and regulatory review. An economic evaluation of a proposal should always explain who will be affected and to what degree, whether it is an agency, sections of the community, industry or individuals (Marilyn, 2009).

The main sources of uncertainty arising at the beginning of a mine project can be categorized into three groups: exploration uncertainties, engineering uncertainties and economic uncertainties.

Cost is another source of uncertainty when evaluating a mine project. The economic evaluation component of the feasibility study is based on the information that provides an answer to the question, 'what is it going to cost?' Since the estimation of capital and operating costs is an important requirement for open pit mine evaluation, uncertainty in costs arises due to the lack of engineering or economic information at the beginning of the mine project (Fatemah*et al.*, 2015).

Mining is based on the minerals on or buried in the ground. Mining involves large risks, while requiring heavy capital investment with relatively long payback periods when compared with other business sectors. Thus, careful assessment and decisions are required when investing in mining in order to reflect the distinctive characteristics of the sector. Investment decisions in mining projects are made after an economic evaluation, which is common in most business ventures. The construction of a realistic investment model is required in the evaluation of a proposed mine project (Zana *et al.*, 2015). The risk associated with a mining project can be classified as internal and external (sources). Internal sources of uncertainties relate to the ore body model and grade distributions, as much as technical mining specifications (ground condition, equipment capacities, workforce and management). The external sources consist of commodity price, political/country risk, environmental conditions, legislation and government policy. Lilford*et al.*, (2005) studied project valuation methodologies for mineral deposits. The purpose of this paper is to present available mine project evaluation methods and more specifically Discounted Cash Flow (DCF), and Monte Carlo Simulations (MCS) and subsequently apply them to a mine project using different discount rates.

The economic analysis is necessary for making decisions concerning extraction and processing of mineral resources: the engineering design of the development of a deposit, the acquisition or sale of a deposit, a change in the mining and processing methods, a change in the extracting rate and/or extraction level, an assessment of value of assets for taxes purposes; re-evaluation of the investment programme; the evaluation for the purposes of leasing. The basic procedure of any evaluation is to compare the consequences or relative values of all possible alternative actions and then make informed decisions based upon the observed results. The challenge is exacerbated by having to distil technical complexity into a financial model that is usually designed to focus only one or two key valuation indicators, such as Net Present Value (NPV) or Internal Rate of Return (IRR) or Payback period (Topal, 2008). The economic analysis must answer to two important questions: does the investment project satisfy the objectives of the firm? And how does this project compare with other investment opportunities?

II. RESEARCH METHODOLOGY

The study was carried out in Ondo State, Nigeria. The study area is located in south western Nigeria; the study area share borders; in the North by Ekiti and Kogi states, in the west by Osun and Ogun states and in the South by the Atlantic Ocean. The temperature throughout the year ranges between 21^{o}C to 29^{o} C and humidity is relatively high. The annual rainfall varies from 2,000mm in the southern areas to 1,150mm in the northern areas. Ondo State is located entirely within the tropics. The grids of Ondo State are around latitude 7^{o} 10' 0" N and longitude 5^{o} 5' 0"E [North American Conference Series, (NACSS) 2014]. Ondo State is richly blessed with varied and favorable ecological and climatic conditions with vegetation ranging from mangrove swamps to the southern coastal riverine areas through the rainforest of the mid-lands to the derived savannah in the northern part of the state. The tropical climate of the state is broadly of two seasons; rainy season (April – October) and dry season (November – March).

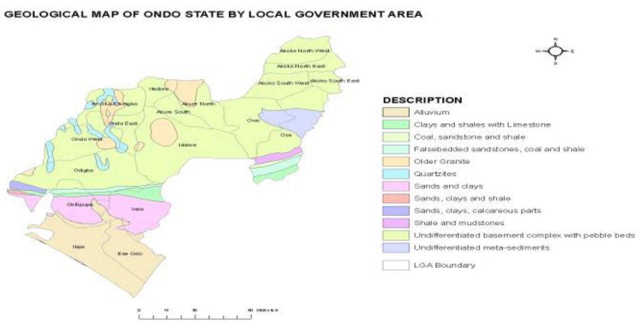

Figure 1: Map of Ondo State (Source: Google Map, 2018)

III. RESULTS AND INTERPRETATION

Table 1: Initial Investment and Cashflows for Quarry A and B

	Quarry A (NGN)	Quarry B (NGN)
Initial investment	-200 × 10^6	-350 × 10^6
Year 1	600 × 10^6	750 × 10^6
Year 2	750 × 10^6	900 × 10^6
Year 3	900 × 10^6	1000 × 10^6
Year 4	800 × 10^6	1200 × 10^6
Year 5	920 × 10^6	1250 × 10^6

Table 1 reveals the secondary data which are the initial investments and cash flows data for five (5) years obtained from the two quarries in Ondo States.

2.1 EVALUATION METHODS CALCULATION RESULTS

Table 2: Quarry A NPV, IRR and PI Results

	Cash flow (NGN)		
Initial investment	-200 × 10^6	Discount rate	12%
Year 1	600 × 10^6		

Year 2	750 × 10^6		
Year 3	900 × 10^6		
Year 4	800 × 10^6		
Year 5	920 × 10^6		
NPV IN	2804.659 ×10^6		
NPV OUT	-200 × 10^6		
NPV	2604.659 ×10^6		
IRR	321%		
PI	14.0232543		

Table 3: Quarry B NPV, IRR and PI Results

	Cash flow (NGN)		
Initial investment	-350 × 10^6	Discount rate	10%
Year 1	750 × 10^6		
Year 2	900 × 10^6		
Year 3	1000 × 10^6		
Year 4	1200 × 10^6		
Year 5	1250 × 10^6		
NPV IN	3772.702 ×10^6		
NPV OUT	350 × 10^6		
NPV	3422.702 ×10^6		
IRR	231%		
PI	10.7791482		

Table 2 and Table 3 shows the calculation results for NPV, IRR and PI from the Microsoft excel sheets for all the quarries considered from the data in Table 1 and Discount rates. The yellow color reflects the values for NPV for each quarries, the orange color reflects the values for IRR for each quarries and the grey color reflects the values for PI for each quarries. The results shows that all the quarries met the decision criterion for all the evaluation methods, which shows that the projects are worthy of investment.

The decision criterion for the evaluation methods are:

1. NPV: when its equals to zero or greater than 1, the project is worthy of investment ,
2. IRR: when its greater than 1, the project is worthy of investment and
3. PI: when its greater than 1, the project is worthy of investment.

2.2 @RISK ANALYSIS RESULTS FOR QUARRY A

The results in Figure 2 - 7 show the Probability Distribution and Ascending curves obtained from the @RISK analysis respectively for Quarry A. Figure 2 shows that the NPV will be in the range of 2.60465E+009 and 2.0465E+009 with the probability of 90% and mean of 2.605E+009 and std dev of 4.083. This result shows that NPV VALUE is very high which makes the project worthy of investment. Figure 3 shows the sensitivity graph for the case of 90% probability and it reveals that the possibility of losing money is very low and the probability of getting a positive NPV is 95% as indicated in the figure. Figure 4 shows that the PI will be found between -2.4 and 30.5 with the 90% probability. The minimum and the maximum values of PI are found as -25.3993 and 54.285 respectively with a mean of 14.023 while Figure 5 shows the ascending cumulative density curve indicating a positive PI with the same result obtained from figure 4. Figure 6 shows that the IRR will be found between -1324% and 1966% with the 90% probability. The minimum and maximum values of IRR are found as -3468.7% and 4451.7% respectively with a mean of 321.2% while figure 7 shows ascending cumulative density curve for IRR. This result reveals the accuracy of using the @RISK to analyze with the result from excel. It also shows that the NPV, PI and IRR met the decision criterion for a project worthy of investment.

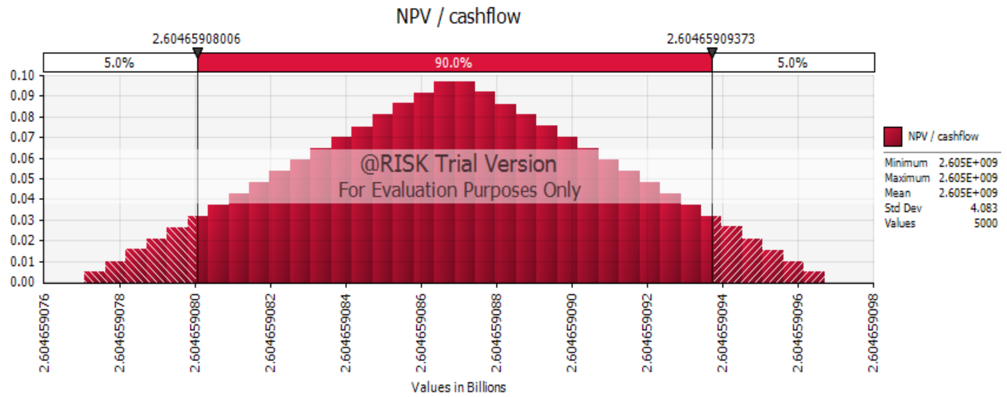

Figure 2: Probability Distribution for Quarry A NPV with 90%

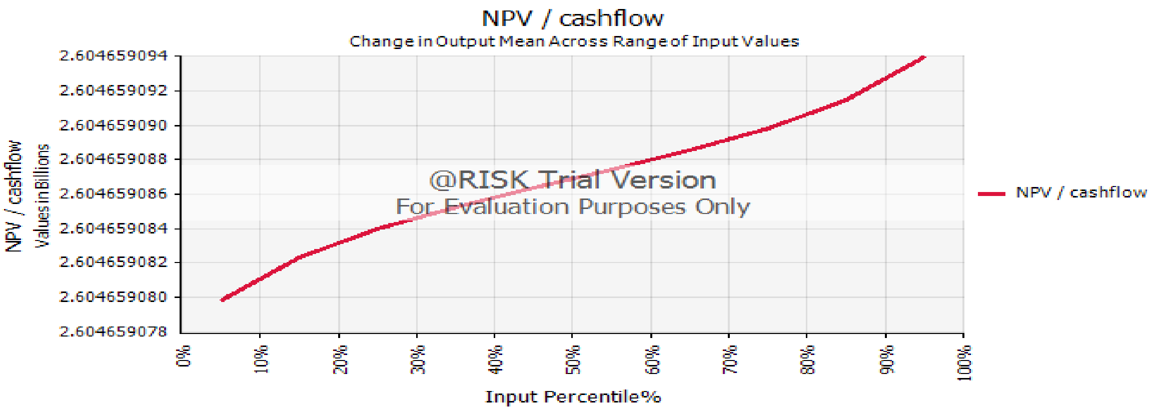

Figure 3: Plot of NPV / Cashflow against Input Percentage Showing Sensitivity graph for quarry against NPV

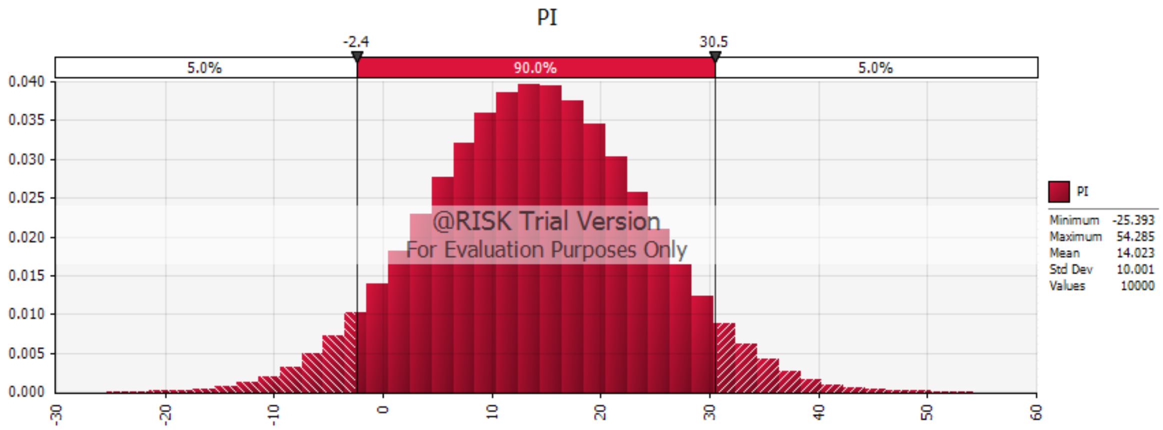

Figure 4: Probability Distribution for Quarry A PI

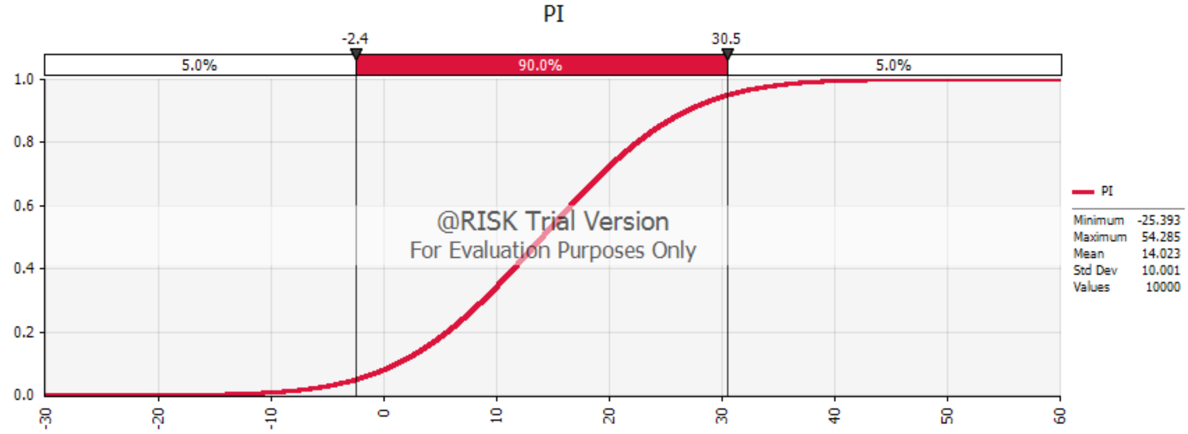

Figure 5: Ascending Cumulative Density Curve Indicating a Positive PI for quarry A

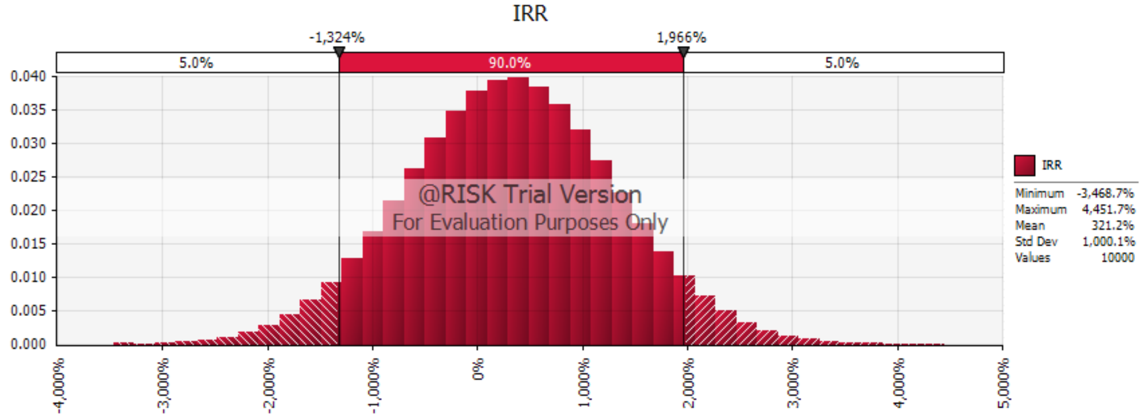

Figure 6: Probability Distribution graph for Quarry A IRR

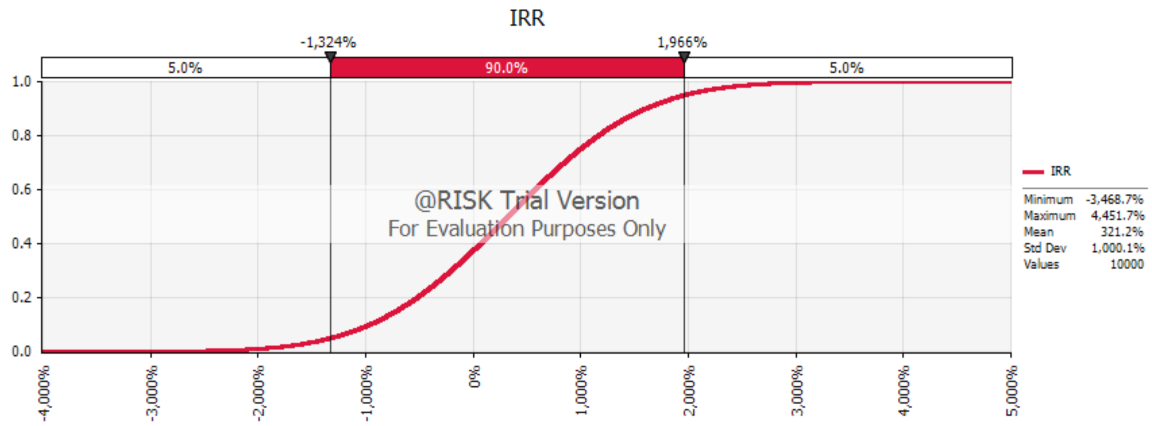

Figure 7: Ascending Cumulative Density Curve Indicating a Positive IRR for quarry A

2.3 @RISK ANALYSIS RESULTS FOR QUARRY B

The results in Figures 8 - 11 shows the Probability Distribution and Ascending curves obtained from the @RISK analysis respectively for Quarry B. Figure 8 shows that the NPV will be in the range of 3006.55 and 3992.31with the probability of 90% and mean of 3500 and std dev of 204.5. This result shows that NPV VALUE is very high which makes the project worthy of investment. Figure 9 shows that the PI will be found between 10.042 and 11.516 with the 90% probability. The minimum and the maximum values of PI are found as 9.7867 and 11.848 respectively with a mean of 10.7791. Figure 10 shows that the IRR will be found between 13.5% and 86.5% with the 90% probability. The minimum and maximum values of IRR are found as 0.501% and 99.712% respectively with a mean of 50% and Figure 11 shows the sensitivity graph of IRR for input ranked by effect on the output mean showing the baseline of 50%, input high of 87.191% and input low of

12.808%. This result reveals the accuracy of using the @RISK to analyze with the result from excel. It also shows that the NPV, PI AND IRR met the decision criterion for a project worthy of investment.

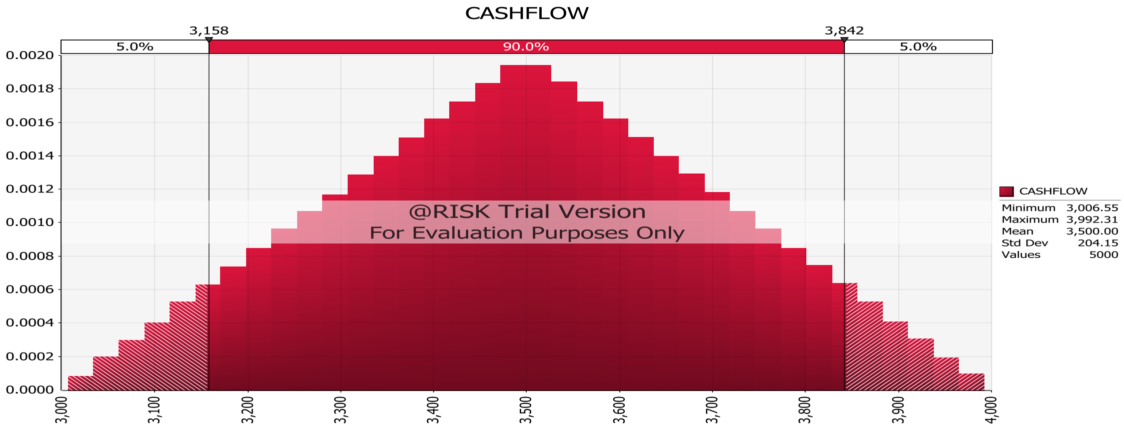

Figure 8: Probability Distribution graph for Quarry B NPV

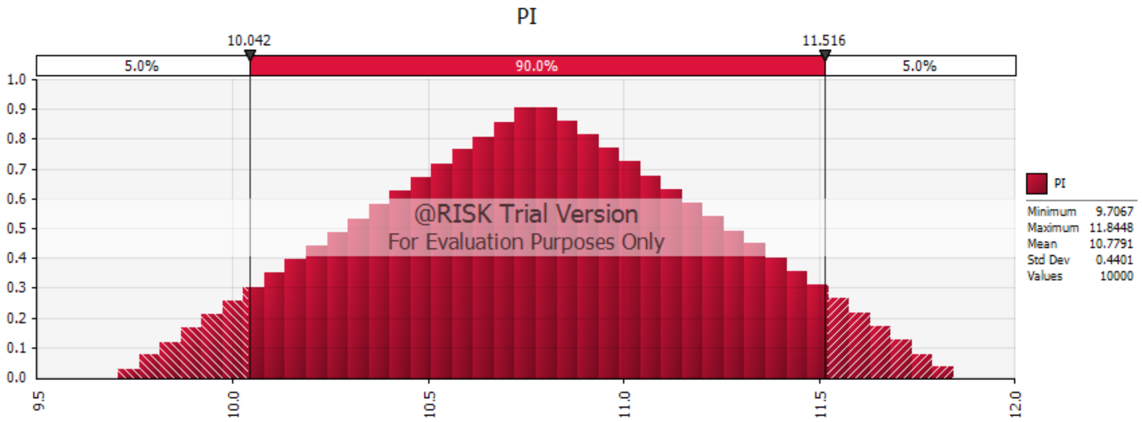

Figure 9: Probability Distribution graph for Quarry B PI

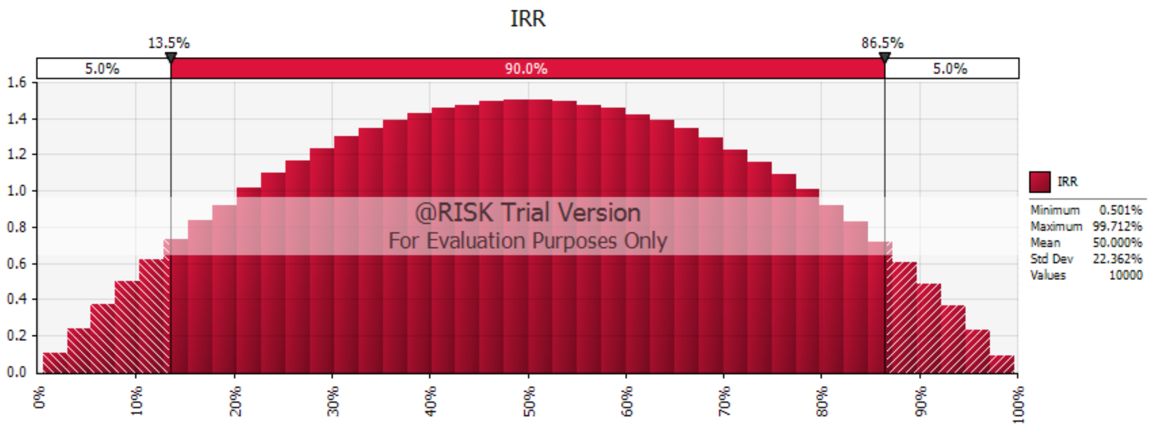

Figure 10: Probability Distribution graph for Quarry B IRR

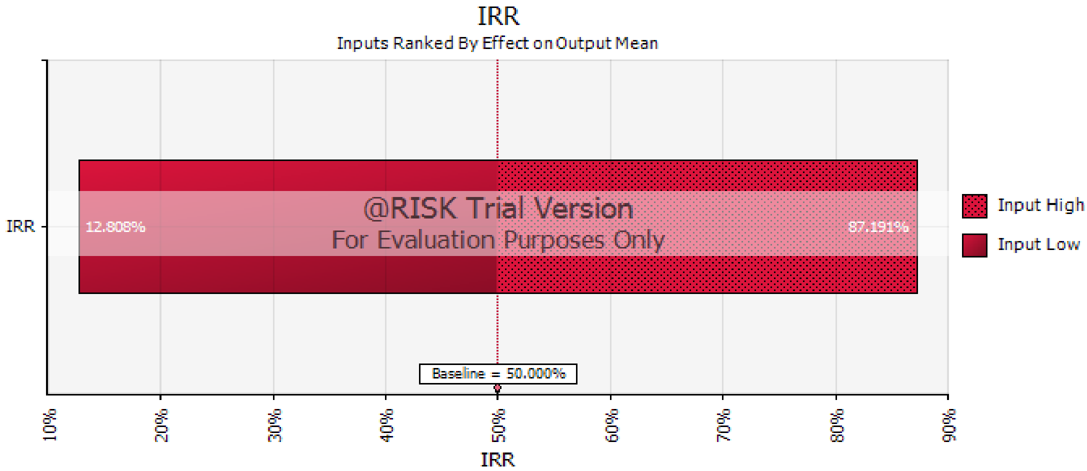

Figure 11: Sensitivity graph of Tornado Graph for Quarry B IRR

IV. CONCLUSION

Economic evaluation must be carried out before and during operation to check the financial state of the company.The Quarries considered, met the decision criterion for each evaluation methods used in analyzing the investment decisions and it proves them to be worthy of investment. These methods can be easily analyzed and interpreted with the aid of Monte Carlo simulations using @RISK.Triangular distribution was used and it reflects been real for a quarry company because of the price ranges. The Input distribution reflects reality, so the output is valid.

V. RECOMMENDATION

I. When a mining Project is evaluated, all relevant uncertainties should be evaluated in full details to acquire real and accurate results. Because real and accurate estimation of the uncertainties have an important role on accuracy of the simulation of the financial model.
II. Quarry companies should use the new technologies to better manage their project investments and financial models.
III. A trained personnel should be employed to manage the financial sector of the company to avoid mismanagement.
IV. An investor could try to determine a default point then use historical data to develop distributions of revenue and expenses and cash flow and NPV allowing a forecast of the likelihood of default within a particular time frame.

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Oyedele, et.al,"Economic Evaluation of Quarry Operations InOndo State, Nigeria, Using @RISK ForMonte Carlos Simulation"*The International Journal of Engineering and Science (IJES)*, 9(01) (2020): 30-36.