The Investment Scenario Analysis with Real Options Method by Using Monte Carlo Simulation

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Abstract—**In this paper, the real options approach and how it can be used in investment analysis in automotive sector is summarized. A real option attitude of mind that takes ideas from financial options offers a fresh perspective. Then we go on with six basic managerial options. The investment can be deferred, switched, expanded, grew and staged with these options. Monte Carlo method is described and used for a solution method in this study. This approach captures uncertainty in modeling parameters and it is offered newly for option valuing in automotive supplier industry.**

Index Terms— **Investment decisions, Scenario analysis, Monte Carlo Method, Real Options, Strategic investments**

I. Introduction

Strategic investment decisions are very significant for the companies. True investment decisions are the only way for surviving and competing with opponents in the market in banking industry and also in production companies. The best investment strategy must be discussed and applied for survival.

The company will use the investment analysis offered in this study as a selection tool between scenarios in the dynamic environment. This company produces plastic parts for automotive giants such as Mercedes, Toyota, Ford, Renault and Hyundai. The company is located in Gebze between Istanbul and Kocaeli known as industry area. The endorsement of the company is 20 million dollars per year. Approximately there are 750 employees working for this company. With new projects and new orders, the capacity problem has become visible as a strategic decision. For this reason the company is looking for a correct and applicable investment decision.

The company is considering buying some new and bigger injection machines. Due to facility planning some old and small injection machines have to be sold or rented. The cost of these machines is around 40.000-80.000 dollars and the cost is changing due to machine capacity. The total investment amount will be around 750.000 dollars. In our study we try to find the optimum number of new machines that will be purchased by the generated scenario analysis.

We indicated real options method and six managerial options to choose the best option for our investment. And we offered Monte Carlo method for valuing the option price, instead of Black Scholes and Binomial method because of its flexibility and convenience to the scenario analysis.

This study is organized as follows: second section focuses on the previous studies about investment decisions, Monte Carlo Method, Real Options, and on the third section Real Options is briefly mentioned. The fourth section shows types of evaluation in real options. The six basic managerial options are described on the fifth section. Section six focuses on investment scenarios. On section seven, Monte Carlo method is described and section eight gives the formulations of this method. A conclusion part of this study will be mentioned at the last section.

II. Literature Review

Monte Carlo simulation solution method based real options valuation is not studied because of its complexity; this explains why there are few articles about this valuation process.

Michele Moretto examines the effect of competition on investment decisions in an industry in which each firm has a completely irreversible investment opportunity. His "real options" analysis may help explain rapid and sudden developments such as recent investment. [10].

Reinhard Madlenera and Simon Stoverinkb have a study about study the economic feasibility of constructing a 560 MW coal-fired power plant in Turkey, using real options theory. They develop a sequential investment model based on the binomial tree model. The relatively high option value compared to the net present value (NPV) of the project [11]. Michel Benaroch and Robert J. Kauffman used Black Scholes method for real options pricing analysis to evaluate information technology project investments [1].

Armstrong Duku-Kaakyire and David M. Nanang used binomial method to forestry investment analysis of real options theory [2]. Anastasios Michailidis, Konstadinos Mattas also used binomial method for Irrigation Dam Investment Analysis [3]. David J. Vander Veen and William C. Jordan develop an analytical approach for studying machine investment opportunities by using benefit-cost analysis. Machine investment decisions involve determining the number of machines to purchase and their types. Machine utilization decisions involve determining part allocations and production cycles [12]. Qian Wang, D. Marc Kilgour, and Keith W. Hipel developed a numerical technique for evaluating risky projects with fuzzy real options. They evaluate the hybrid variables that represent

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the market risk of a project using an extension of Least Squares Monte-Carlo simulation that produces numerical evaluations of fuzzy real options [13]. Gerardo Blanco shows an investment valuation approach which properly assesses the option value of deferring investments by gaining flexibility. The flexibility allows to abandon and to relocate. His real option valuation approach based on the novel least square Monte Carlo method. Gerardo Blanco, Fernando Olsina and Francisco Garcés compared flexible investment strategy in a real study case with the changing scenarios [14]. Lei Zhu establishes a nuclear power investment evaluation model by employing real options theory with Monte Carlo method to evaluate the value of nuclear power plant from the perspective of power generation enterprises [15]. Chung-Li Tseng and Graydon Barz discuss using real options to value power plants with unit commitment constraints over a short-term period. They formulate the problem as a multistage stochastic problem and propose a solution procedure that integrates forward-moving Monte Carlo simulation with backward-moving dynamic programming [16].

Previous studies mostly prefer other methods instead of Monte Carlo method due to complexity. Conversely this method presents more realistic option price. That is why this method is preferred to use in an application of automotive sector in this study.

III. Real Options

Using options theory is one way to deal with the high level of uncertainty when making decisions in the early phases [4]. A financial option has a value because it gives its owner the possibility to decide in the future whether or not to pay the strike price for an asset whose future value is not known today. A financial option gives a right to make the decision after receiving more information. There are two different types of options; American and European. [7]. In American options one can exercise the option at any time till maturity date however in European type of options exercising the option is not allowed till the expiration.

Real Options could be seen as an extension of financial option theory to options on real assets [5]. Copeland [6] defines a real option as: “the right, but not the obligation, to take an action (e.g. deferring, expanding, contracting, or abandoning) at a predetermined cost called the exercise price, for a predetermined period of time - the life of the option.” In Table I, the explanations of real options variables corresponding to financial options are given.

TABLE I
Financial versus real options [8]

Financial Option	Variable	Investment Project / Real Option
Exercise price	K	Cost to acquire the asset
Stock price	S	Present value of future cash flows from the asset
Time to expiration	T	Length of time option is viable
Variance of stock returns	σ^2	Riskiness of the asset, variance of the best and worst scenario
Risk-free rate of return	r	Risk-free rate of return

IV. Valuing Real Options

One of the advantages with real options compared to many other evaluation methods is the possibility to value different system designs and thereby finding the most economic investment. This is probably the most complicated part of using real options. There are several methods to calculate its value. They all have various assumptions. There are three general solution methods [5].

Black-Scholes-Merton model: The partial differential equation approach calculates the option value by solving a partial differential equation including the value of a replicating portfolio.

Binomial model: The dynamic programming approach lays out the possible future outcomes and folds back the value of optimal future strategy.

Monte Carlo simulation: The simulation approach averages the value of the optimal strategy at the decision date for thousands of possible outcomes.

V. The Six Basic Managerial Options

The presence of managerial options enhances the worth of an investment project. The worth of a project can be viewed as its net present value (NPV) calculated in the traditional way, together with the value of any option. The six basic real options depicting the managerial options can be seen in Table II.

Project worth = NPV + Option value

TABLE II
The basic of real options [8]

Name	Explanation of the real options
The option to defer	Wait until further information reduces market uncertainty
The option to abandon	Dispose of an unprofitable project.
The option to switch	Change input/output parameters
The option to expand/contract	Alter capacity depending on market conditions.
The option to grow	Entertain future-related opportunities.
The option to stage	Break up investment into incremental, conditional steps.

In this study, we chose the option to expand. The company has a capacity problem. The injection machines will not be enough for the new orders. When we look at the numbers, the order will be around 100.000 for new Toyota Corolla, 300.000 for new Renault Clio and 350.000 for new Ford Transit. Each project has at least 30 plastic parts. It makes 22.500.000 plastic parts each year. It looks impossible to reach these amounts by current machines. Capacity calculations include %15 scrap. For this reason the company is considering to buy 14 new injection machines. Tonnages of machines will be between 400 and 3000. Due to facility capacity some small old machines should be sold or rented to other companies or sent to our second factory. We will use the option to grow. There will be 3 scenarios for machine movements to choose the best option.

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VI. Scenarios

The company is considering to buy 14 new injection machines and to get rid of 12 old injection machines. The tonnages of old machine are between 500 and 1000 tons. There are three options for old machines. Firstly they can be sold or they can be moved to the second factory of the company which is 250 km far away. The last way is to continue production with old machines in a subcontractor firms which is max 50 km far away from the company.

The tonnage of new injection machines will be between 400 and 3000 tons. 9 machines will be bigger than 1500 tons and 5 machines will be smaller than 1500 tons. The injection machine costs will be around 45.000 and 100.000 dollars due to its tonnage (clamping force).

The second factory of the company is 250 km far away from the first factory. The second factory is smaller than the first one. Generally clamping force of the machines are less than 1000 tons in the second factory.

In our study, there will be 3 scenarios for the investment analysis. These scenarios are determined by the production department of the company and they lie on the table of that department. Traditional NPV techniques could not take the flexibility into account and that is why we use real options valuation in this study. In all scenarios 14 new injection machines will be bought and 12 old injection machines will be moved. The movements of old machine will create the scenarios.

First scenario; 9 old injection machines whose clamping force is under 1000 tons, will be sold to other companies. The rest 3 old machines will be brought to the second factory of the company. And in the second factory 2 machines whose clamping force is less than 500 tons will be sold to other firms due to facility capacity. In this scenario, we get rid of the maintenance costs of 9 machines. But there will be a transportation cost for 3 machines to bring them to the second factory. We have saving in the second factory, 2 machines are sold and there will be no maintenance cost.

Second scenario; 8 old injection machines whose clamping force is under 1000 tons, will be sold to other companies. And 4 old injection machines will be sent to subcontractor firms. Subcontractor firms will continue production with these machines for us. There will be a rent cost for machine place. And there will be still maintenance cost for these 4 machines.

Third scenario; 6 old injection machines whose clamping force is under 1000 tons, will be sold to other companies. 3 old machines will be brought to the second factory of the company. And in the second factory 2 machines whose clamping force is less than 500 tons will be sold to other firms due to facility capacity. And 3 old injection machines will be sent to subcontractor firms. Subcontractor firms will continue production with these machines for us.

VII. Monte Carlo Method

This approach calculates the options value by randomly simulating thousands of possible future scenarios for uncertain variables. The most commonly used simulation model is the well-known Monte Carlo simulation method. It provides a simple and flexible method for valuing. Multiple random factors can be dealt with. Options on multiple assets, random volatility or random interest rates are not problem for this method. Monte Carlo simulation lets the incorporation of more realistic assets price processes. For example jumps in asset prices and more realistic market conditions can be used in valuing.

In general, the Monte Carlo simulation method would give the same result as the rigorous economics-based option valuation models such as the Black-Scholes equation and the binominal option valuation model, if it is based on the risk-neutral dynamics. However, introducing the risk-neutral dynamics into the Monte Carlo simulation method reduces the simplicity and the transparency of the model. [9].

VIII. Valuation By Simulation

In this method, we can see that the value of an option is the risk-neutral expectation of its discounted pay-off. An estimate of this expectation can be obtained by computing the average of a large number of discounted pay-offs. Below the analogies between financial options and real options are shown. [9].

The option price is calculated with the formulas that are shown below.

$$C_{0,j} = \exp(-\int_0^T r_u du) C_{T,j} \tag{1}$$

It simplifies to;

$$C_{0,j} = \exp(-rT) C_{T,j} \tag{2}$$

where r is risk-free interest rate and $C_{T,j}$ is the pay-off of the contingent claim at the maturity date T, for this simulation (j).

The simulations are repeated M times and average of all the outcomes is taken;

$$\hat{C}_0 = \frac{1}{M} \sum_{j=1}^{M} C_{0,j} \tag{3}$$

Standard error (SE) can be estimated as the standard deviation (SD) of $(C_{0,j})$

$$SE(\hat{C}_0) = \frac{SD(C_{0,j})}{\sqrt{M}} \tag{4}$$

$$SD(C_{0,j}) = \sqrt{\frac{1}{M-1} \sum_{j=1}^{M} (C_{0,j} - \hat{C}_0)^2} \tag{5}$$

In order to implement Monte Carlo simulation geometric Brownian motion (GBM) process needs to be simulated for the for the underlying asset at any time t,

$$dS_t = (r - \delta) S_t dt + \sigma S_t dz_t \tag{6}$$

where δ is the dividend yield for financial option but a value decreasing the option value in real options. The best way to simulate a variable following GBM is with the process for the natural logarithm which follows arithmetic Brownian motion and is normally distributed [9]. Suppose $x_t = \ln(S_t)$, then we have

$$dx_t = \nu dt + \sigma dz_t \tag{7}$$

$$\nu = r - \delta - \frac{1}{2}\sigma^2 \tag{8}$$

Equations (7) and (8) can be transformed into

$$\Delta x = \upsilon \Delta t + \sigma \Delta z \tag{9}$$

$$x_{t+\Delta t} = x_t + \upsilon \Delta t + \sigma (z_{t+\Delta t} - z_t) \tag{10}$$

In terms of the asset price S we have;

$$S_{t+\Delta t} = S_t \exp(\upsilon \Delta t + \sigma (z_{t+\Delta t} - z_t)) \tag{11}$$

where z_t would normally be defined as being equal to zero.

$$s_{t_i} = \exp(x_{t_i}) \quad (12)$$

$$x_{t_i} = x_{t_{i-1}} + \upsilon\Delta t + \sigma\sqrt{\Delta t \varepsilon_i} \quad (13)$$

To obtain the estimate of the call price we simply take the discounted average of these simulated pay-offs; [9].

$$C_0 = \exp(-rT)\frac{1}{M}\sum_{j=1}^{M}\max(0, S_{T,j} - K) \quad (14)$$

Sensitivity analysis should also be made on real option value due to changes in present value of future cash flows, standard deviation of the best and worst scenario, time to expiration and risk free rate of return by equation below.

$$\delta = \frac{\partial C}{\partial S} \approx \frac{C(S+\Delta S) - C(S-\Delta S)}{2\Delta S} \quad (15)$$

$$\nu = \frac{\partial C}{\partial \sigma} \approx \frac{C(\sigma+\Delta\sigma) - C(\sigma-\Delta\sigma)}{2\Delta\sigma} \quad (16)$$

$$\theta = \frac{\partial U}{\partial t} \approx \frac{C(t+\Delta t) - C(t)}{\Delta t} \quad (17)$$

$$\rho = \frac{\partial C}{\partial r} \approx \frac{C(r+\Delta r) - C(r-\Delta r)}{2\Delta r} \quad (18)$$

IX. Conclusion

In this paper, we mentioned real options theory to decide the investment strategy for the company that produces plastic parts for automotive sector. Six basic managerial options are described. Due to our capacity problem, we chose option to grow. For this option we have three scenarios. These scenarios are investigated by the production department of the firm and mostly detailed on the scenarios. The difference between the scenarios is the number of machines that will be bought, rented or sold. The option value will show us the best scenario to choose.

Monte Carlo method is chosen for valuing the option price. The major advantage of the simulation is that the simulation theory is relatively straightforward. Simulation methods are easier to apply than analytical methods. Whereas analytical models may require us to make many simplifying assumptions, simulation models have few such restrictions, thereby allowing much greater flexibility in representing the real system.

For future works multi criteria methods named AHP, TOPSIS or ELECTRE can be integrated to the model to take the point of view of experts. Or real options using Monte Carlo method integrated multi objective methods can be used for determining the optimum number of machines to be removed. For some vague conditions there is a very useful technique labeled as fuzzy technique could be used for such situations.

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