THE INVESTMENT SCENARIO ANALYSIS OF SUPLEMENTARY MACHINES WITH REAL OPTIONS METHOD BY USING MONTE CARLO SIMULATION

(MAKİNE YATIRIMINDA GERÇEK OPSİYONLARLA SENARYO ANALİZİ-MONTE CARLO SİMÜLASYON YAKLAŞIMI)

by

Burak KAYSERILIOĞLU, B.S

Thesis

Submitted in Partial Fulfillment

of the Requirements

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ABSTRACT

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 six basic managerial options are mentioned. 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.

Investment is the purchase or creation of assets in order to have benefits in the future. By using financial resources to purchase a machine/ building or other asset is an important investment decision. That decision will bring profit to an organization after a period of time. Strategic investment decisions are very significant for the companies. One of the most important long term decisions for any business relates to investment. True investment decisions are the only way for surviving and competing with opponents in the market. The best investment strategy must be discussed and applied for survival.

RESUME

On fait le compte-rendu de la méthode des options réelles et comment elle peut être utile pour l'analyse d'investissement dans le secteur d'automative. L'option réelle nous offre un différent point de vue de l'esprit et une nouvelle perspective en étant inspiré par des options financières. Et puis on parle des 6 principales types des options gestionnaires. On peut incliner, changer, agrandir, élever et préparer l'investissement grâce à ces options. La méthode Monte Carlo est décrit et utilisé comme une méthode de solution dans cette recherche. Cette approche attrape les incertitudes des paramètres des modelés et elle est offerte de nouveau pour l'évalution des options dans l'industrie des fournisseurs d'automative.

Les décisions des investissements stratégiques sont essentielles pour les sociétés. Toutes les décisions à long terme sont toujours liées aux investissements. L'investissement c'est l'achat ou la création des biens afin d'avoir des bénéfices à l'avenir. L'achat d'une machine, d'un immobilier ou des autres biens en utilisant des ressources financières est une décision importante de l'investissement. Cette décision va emmener profit à l'entreprise au bout d'une certaine période. Les décisions correctes de l'investissments sont les seuls moyens de survivre dans le marche avec des concurrents. La discussion et l'approbation sont indispensable pour trouver la meilleure stratégie d'investissement qui va nous aider a survivre dans le marche.

ÖZET

Gerçek opsiyonlar metodu ve bu methodun otomotiv sektöründe bir yatırım analizinde nasıl uygulanabileceğine değinilmiştir. 6 temel yönetimsel opsiyon açıklanmıştır. Bu opsiyonlarla yatırım ertelenebilir, büyütülebilir, küçültülebilir, iptal edilebilir, zamanlaması değiştirilebilir. Bu yatırım analizi için Monte Carlo Metodu seçilip, açıklanmıştır.

Stratejik kararlar bir firma için çok önemli ve hayatidir. Bir işteki en önemli uzun dönem planları yatırımlardır. Finansal kaynakları kullanarak makina, bina veya herhangi bir taşınmaz mülk almak en önemli yatırım kararlarındandır. Ancak iyi yapılmış yatırımlarla firmalar hayatta kalabilir ve rakipleriyle rekabet edebilirler. En önemli yatırım analizi tartışılmalı ve uygulanmalıdır.

Bu çalışmada otomotiv sektöründeki bir firmanın kapasite artışına karşılık büyüme ve yeni makinalar alma yatırımı için Monte Carlo metodu kullanılarak en karlı metod hesaplanmıştır.

1.INTRODUCTION

Strategic investment decisions are very significant for the companies. One of the most important long term decisions for any business relates to investment. Investment is the purchase or creation of assets in order to have benefits in the future. By using financial resources to purchase a machine/ building or other asset is an important investment decision. That decision will bring profit to an organization after a period of time. True investment decisions are the only way for surviving and competing with opponents in the market. The best investment strategy must be discussed and applied for survival.

Key points for investment decisions are:

1.What is the scale of the investment - can the company afford it?
2.How long will it be before the investment starts to yield returns?
3.How long will it take to pay back the investment?
4.What are the expected profits from the investment?
5.Could the money that is being ploughed into the investment yield higher returns elsewhere?

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 considers 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.

Real options method is described and applied in this study. An option is a right, but not an obligation. The key point of an option is that cost of exercising the option, of using one's right to do an action. It is in this respect that an option has value. This is the feature that makes difference between an option and a choice or an alternative. Options are contracts in the financial markets. The options specify the price at which the holder of the option can buy or sell some asset, such as a stock, some commodity, or foreign exchange.

There are six basic managerial options. These are;

- Option to defer
- Option to abandon
- Option to expand
- Option to switch
- Option to grow
- Option to stage

We chose the option to grow for our investment with 3 scenarios 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. Halton defined Monte Carlo method as "representing the solution of a problem as a parameter of a hypothetical population, and using a random sequence of numbers to construct a sample of the population, from which statistical estimates of the parameter can be obtained." He defined Monte Carlo simulation as a computerized mathematical technique that allows people to account for risk in quantitative analysis and decision making. This method is widely used in finance, project management, energy, manufacturing, engineering, research and development, insurance, oil & gas, transportation, and the environment.

This master thesis 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. Then Monte Carlo method is described and section eight gives the formulations. A conclusion part of this study will be mentioned at the last section.

2. 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. Monte Carlo method is stochastic technique that is based on the use of random numbers and probability statistics to investigate problems.

Moretto (2007) 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 or explain the late take-off phenomenon of prolonged start-up problems.

Madlenera and Stoverinkb (2010) have a study about 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. Another advantage of the real options analysis for a staged or sequential investment is to deliver and beside the option value of the investment, the optimal strategy for exercising the option.

Benaroch and Kauffman (1999) used Black Scholes method for real options pricing analysis to evaluate information technology project investments. It provides a formal theoretical grounding for the validity of the Black-Scholes option pricing model in the context of the spectrum of capital budgeting methods that might be employed to assess IT investments; it shows why the assumptions of both the Black-Scholes and the binomial option pricing models place constraints on the range of IT investment situations that one can evaluate that are similar to those implied by traditional capital budgeting methods such as discounted cash flow analysis; and it presents the first application of the Black-Scholes model that uses a real world business situation involving IT as its test bed.

Duku and Nanang (2004) used binomial method to forestry investment analysis of real options theory. Their study provides an empirical application. It compares a forestry investment using the static Faustmann model and the real options approach. Four management options are used for the real options approach: an option to delay, an option to expand, an option to abandon and multiple options that evaluated all three options together.

Michailidis and Mattas (2007) also used binomial method for Irrigation Dam Investment Analysis. Their work provides an empirical application, which compares an irrigation dam investment using the static Net Present Value (NPV) model and the real options approach and shows how it can be adopted to model uncertainty and managerial flexibility in dam management.

Veen and Jordan (2006) 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.

Wang and Kilgour (2011) developed a numerical technique for evaluating risky projects with fuzzy real options. They evaluate the hybrid variables that represent the market risk of a project using an extension of Least Squares Monte-Carlo simulation that produces numerical evaluations of fuzzy real options.

Blanco (2011) 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

Zhu (2012) 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. Economic uncertainty factors have been taken into account in the model and the model is solved.

Tseng and Barz (2000) 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.

Wajs (2000) focused on the NPV forecast values for investment strategy in the form of an investment project for a municipal solid waste dump. Typical cash flow decision problem usually is analyzed with ordinary spreadsheet models. In the investment practice, the investment evaluation criterion, i.e. minimization of variance *V*(NPV) and standard deviation σ(NPV). The benefits of Monte Carlo simulation are saving in time and resources.

Boyle (1997) discusses some applications of the Monte Carlo method to security pricing problems, with emphasis on improvements in efficiency. Variance reduction methods that have proved useful in finance are mentioned. Then the use of deterministic low-discrepancy sequences, for the valuation of complex derivative securities is described. And he summarized some applications of the Monte Carlo method to the estimation of partial derivatives or risk sensitivities and to the valuation of American options.

Monniaux (2001) introduces a new method, combination of random testing and abstract interpretation, for the analysis of programs featuring both probabilistic and non-probabilistic nondeterminism. His study discusses complexity and optimization issues and end with some experimental results.

Rodriguez (2006) provides a detailed analysis of the Least Squares Monte Carlo Simulation Method. The accuracy of the method is assessed when valuing stylized real options as maximum, compound or mutually exclusive options. The analysis is carried out for a large number of call and put options. It is done comparing alternative polynomial families and simulation methods, including moment matching techniques and low-discrepancy sequences. Unlike previous analysis of the method, they show also that the choice of the best simulation method is contingent on the problem in hand. The accuracy of the method depends on the payoff function and seems to converge, increasing both the number of basis and the number of simulated paths.

The paper of Amédée (2011) aim to show that the accuracy of real estate portfolio valuations can be improved through the simultaneous use of Monte Carlo simulations and options theory. Their method considers the options embedded in Continental European lease contracts drawn up with tenants who may move before the end of the contract. They combine Monte Carlo simulations for both market prices and rental values with an optional model that takes into account a rational tenant's behavior. Their main findings are that simulated cash flows which take account of such options are more reliable that those usually computed by the traditional method of discounted cash flow. Moreover, this approach provides interesting metrics, such as the distribution of cash flows. However, some limitations are inherent to our model: these include the assumption of the rationality of tenant's decisions, and the difficulty of calibrating the model, given the lack of data. After a brief literature review of simulation methods used for real estate valuation. Finally, using an empirical example, we analyze the sensitivity of the model to various parameters, test its robustness and note some limitations.

Monte Carlo method presents more realistic option price. That is why this method is preferred to use in an application of automotive sector in this study.

3.FINANCIAL OPTIONS

Financial options are financial instruments that derive their value from one or more other financial instruments or indices. For example, a stock option derives its value from the stock it is based on. They are one of three classes of financial derivatives, the other two being forwards and futures which are outside the scope of this thesis. More specifically, a financial option is an exchange-traded option. An exchange is a regulated institution that facilitates the exchanging of financial instruments between buyers and sellers.

It is clear that, like financial options, real options provide the firm with an opportunity to limit its downside risks while allowing for profit on the upside. As a result, not only is the variance of future cash flows reduced, but the expected value of these cash flows is also increased. But, at what cost to the firm? To compare the use of financial options as alternative risk management tools, it is important to understand where options come from, what costs are associated with acquiring and exercising these options over time, and what the other key differences of financial options are.

Financial options or derivatives strategies can in theory be designed to yield the same contingent payoff structure (assuming there are derivatives traded on the corresponding underlying variables). Either alternative could be used to help reduce costs associated with excessive risk in the firm, and would thus enhance firm value. For instance, there are significant costs associated with setting up a global network of production facilities, including investing in new plants in foreign countries, reconfiguring the firm’s supply chain, maintaining excess capacity at several plants, losing economies of scale, and incurring costs associated with switching.

4. REAL OPTIONS

Traditional discounted cash flow approaches cannot properly capture management's flexibility to adapt and revise later decisions in response to unexpected market developments. Traditional approaches assume an expected scenario of cash flows and presume management's passive commitment to a certain static operating strategy.

The real world is characterized by change, uncertainty and competitive interactions as new information arrives and uncertainty about market conditions is resolved, management may have valuable flexibility to change its initial operating strategy in order to capitalize on future opportunities or to react so as to mitigate losses. This managerial operating flexibility is like financial options and it is named as real options or strategic options. Using options theory is one way to deal with the high level of uncertainty when making decisions in the early phases. (Hull,1993)

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; these are American and European options. (Gustasson, 2011) One can exercise the option at any time till maturity date in American options, on the other hand exercising the option is not allowed till the expiration in European type of options

Real Options could be seen as an extension of financial option theory to options on real assets. Copeland defines a real option as: "the right, but not the obligation, to take an action at a predetermined cost called the exercise price, for a predetermined period of time - the life of the option.". (Copeland, 2001) The explanations of real options variables corresponding to financial options are shown in Table I.

Table 1. Option Variables

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

The comparison between the real options and financial options are given below.

- Financial options are short maturity, usually in months; real options are longer maturity and usually in years and decades.
- Financial options cannot control option value by manipulating stock prices, however real options can increase strategic option value by management decisions and flexibility
- Financial options are competitive or their market effects are irrelevant to its value and pricing. Real options are like competition. The market value and stakeholders drive the value of a strategic option.
- In financial options values per option contract are usually small, but when aggregated can be in the millions or billions. In real options major million and billion dollar decisions are represented by a single option.
- In financial options underlying variable driving its value is equity price or price of a financial asset. Volatility can be calculated from observed historical market prices. In real options underlying variables are free cash flows, which in turn are driven by

competition, demand and management. Volatility is an assumption without basis because there are no historical pricing data.

- Financial options are calculated using closed form partial differential equations and simulation/variance reduction. Real options are calculated using closed form equations and binomial lattice with simulation of the underlying variables. It is also calculated as the difference between NPV of a flexible project and NPV of an inflexible project. (Mun, 2006)

5. SIX BASIC MANAGERIAL OPTIONS

The presence of managerial options increases 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.

$$\text{Project worth} = \text{NPV} + \text{Option value}$$

Table 2. Option Types

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.

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.

5.1 The Option to Defer

The deferral option gains its value from reducing uncertainty by delaying an investment until more information has arrived. Delaying to invest in a project may be beneficial if more information or changing conditions may increase the value of the project. For example, a drug maker can want to delay the decision to build a new manufacturing plant for a newly approved drug until a better understanding of the market performance of the compound has developed. In this example, key uncertainties may be related to product performance, pricing, market penetration, and competitive entry. The option to defer investment has been examined by McDonald and Siegel. They explored the practical importance of the value of waiting to invest by supposing that a firm is considering investing a synthetic fuel plant that cannot be used for any other purpose. So, it can be found that, if the investment expenditures are irreversible, option to defer is especially valuable. Moreover, by computing examples of the option value and investment rule for a wide variety of parameters, authors also summarized that timely considerations are really important. In addition to this Brach argues that the value of waiting to invest may be decreased or destroyed by the value a company creates from a competitive position that does not allow for waiting. (Song, 2006)

5.2 The Option to Change Scale

Managerial flexibility can be accepted to change capacity for responding the market conditions with the option to change scale. This can lead to a project being downsized, expanded, or narrowed in its focus. For example, as the demand for a specific product will pick up, the manufacturing plant managers may plan to expend more investment to expand product capacity in order to capture the opportunity. Nevertheless, if the specific product is not as profitable as expected to continue investing, the managers will not expand the plant. Additionally, Pindyck shows the value involved in the capacity choice utilization of facilities. The capacity choice should be estimated according to the trade-off between the higher fixed costs for producing extra capacity and higher value generated. (Song, 2006)

5.3 The Option to Switch

The real option to switch captures the managerial flexibility to change any given business. This includes exchanging input or output parameters, volume, process and global locations From the aspect of input, Kulatilaka studies the option to switch between two different energy forms in running a plant. By replacing the expensive inputs of a product, the firm can use the cheaper input to run a plant, which will help the firm to save cost and enhance the value. Moreover, the Kulatilaka and Trigeorgis also present a discussion of option to switch between alternative modes of operation, possible at specified switching costs. They summarized that, without switching costs, the value of a flexible project may be equivalent to the value of a rigid project. Other examples of switch options may be related to managerial flexibility to choose between expensive output and cheap one. (Song, 2006)

5.4. The Option to Abandon

The option to abandon can be seen as an American put option. Assuming a project is at a market situation, managers may decide to stop the project to save their costs. Myers and Majd discuss a choice between production technology A with an active secondhand market and technology B without it due to specialization of its equipment. They summarized that, if the production may be halted before the machines are worn out, the technology A is worth more than the technology B without managerial flexibility. In addition to this, the option to abandon is highly valuable for capital-intensive industries, financial services and new product introductions in uncertain markets. (Song, 2006)

5.5 The Compound Option

The compound options exist when making an investment is viewed as the prerequisite to get the opportunity to enter into the next investment. For example, a large plant construction, as a phased investment, can be phased into design, engineering, preconstruction and final construction. In this kind of investment, investors often keep the right, not obligation, to defer or abandon next phase investment at the end of each phase. As to valuation of the compound option, Trigeorgis showed the nature of the interaction of real options. For the multiple options that is very common in projects involving real options. In addition to these compound options widely consist in staged investments, such as, investment in new technologies, pharmaceutical drug development program, and investments into technology platforms. Moreover, Brach explains that, among projects including the feature of staged-investment, two main sources of risk are technical risk that relates to the ability of the firm to actually carry out successfully the project. Additionally, Li Ming & Zhi Gang applied real option to evaluate R&D project and explained the uncertainties of an R&D project into three stochastic processes. The first uncertainty is the investment cost needed for completing the project; the second uncertainty is about the future yield; the third one is the possibility of stopping this project. (Song, 2006)

5.6 The Option to Growth

Growth option is an option to take on the follow-on projects if the initial investment worked out well (Amram& Kulatilaka,). A company that is making an initial investment in a new market, a new product line, or a new technology A, often chooses growth option. As to these investment including much initial outlays, using the NPV approach to evaluate often give a negative result, which omits the value of growth options. Moreover the decisions may create infrastructure and opportunities for future expansion. For example, investments in R&D contain growth options because they may create a platform of knowledge for future products. Thereby, Growth options are especially important for high-tech, high risk investment. Ottoo values the internal growth opportunities for a hypothetical biotechnology company. By modeling the interaction between current real options and future growth opportunities, it is found that investment in basic R&D is helpful for a firm to gain access to productive technology before its competitors. (Song, 2006)

6. 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.

Table 3. Investment Scenarios

Scenario No	Options
1	-9 old injection machines will be sold to other companies. -3 old machines will be brought to the second factory -İn the second factory 2 machines will be sold to other firms due to facility capacity.
2	-8 old injection machines will be sold to other companies. -4 old injection machines will be sent to subcontractor firms.
3	-6 old injection machines will be sold to other companies. -3 old machines will be brought to the second factory of the company. -In the second factory 2 machines will be sold to other firms due to facility capacity. -3 old injection machines will be sent to subcontractor firms.

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.

7. 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 it finds 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. (Amram, 1999)

- 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.

7.1. Black-Scholes method

The Black-Scholes model is used to calculate the theoretical price of European put and call options, ignoring any dividends paid during the option's lifetime. While the original Black-Scholes model did not take into consideration the effects of dividends paid during the life of the option, the model can be adapted to account for dividends by determining the ex-dividend date value of the underlying stock.
The model makes certain assumptions;

- The options are European and can only be exercised at expiration
- No dividends are paid out during the life of the option
- Efficient markets (i.e., market movements cannot be predicted)
- No commissions
- The risk-free rate and volatility of the underlying are known and constant
- Follows a lognormal distribution; that is, returns on the underlying are normally distributed.

$$C = SN(d_1) - N(d_2)Ke^{-rt} \tag{7.1}$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{S^2}{2}\right)t}{S\sqrt{t}} \tag{7.2}$$

$$d_2 = d_1 - S\sqrt{t} \tag{7.3}$$

C = Call premium
S = Current stock price
t = Time until option exercise
K = Option striking price
r = Risk-free interest rate
N = Cumulative standard normal distribution
e = Exponential term
s = St. Deviation
ln = Natural Log

The model is essentially divided into two parts: the first part, *SN(d1)*, multiplies the price by the change in the call premium in relation to a change in the underlying price. This part of the formula shows the expected benefit of purchasing the underlying outright. The second part, *N(d2)Ke^(-rt)*, provides the current value of paying the exercise price upon expiration The value of the option is calculated by taking the difference between the two parts, as shown in the equation.

7.2. Binomial method

Binomial option pricing is a simple but powerful technique that can be used to solve many complex option-pricing problems. In contrast to the Black-Scholes and other complex option-pricing models that require solutions to stochastic differential equations, the binomial option-pricing model is mathematically simple. The assumption of no arbitrage implies that all risk-free investments earn the risk-free rate of return and no investment opportunities exist that require zero dollars of investment but yield positive returns. The activities of arbitrageurs or speculators are often maligned in the media, but their activities insure that our financial markets work. They insure that financial assets such as options are priced within a narrow tolerance of their theoretical values.

- There are two possible prices for the underlying asset on the next date. The underlying price will either:
  - Increase by a factor of u% (an uptick)
  - Decrease by a factor of d% (a downtick)

- The uncertainty is that we do not know which of the two prices will be realized.
- No dividends.
- The one-period interest rate, r, is constant over the life of the option (r% per period).
- Markets are perfect (no commissions, bid-ask spreads, taxes, price pressure, etc.)

7.2.1.Binomial option model building process

Let us consider that we have a share of a company whose current value is S. In the next month, the price of this share is going to increase by u% (up state) or it is going to go down by d% (down state). No other outcome of price is possible for this stock in next month. Let p be the probability of up state. Therefore the probability of down state is 1-p.

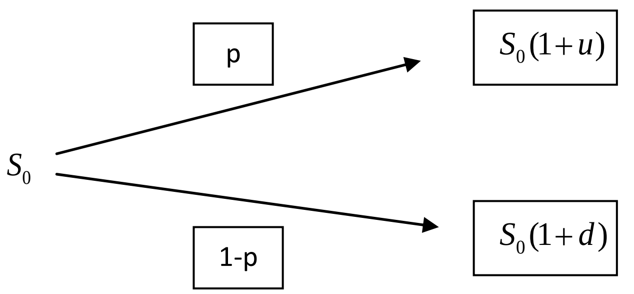

Figure 1.

Assume that call option exists for this stock which matures at the end of the month. Let the strike price of the call option be X. Now in case, the option holder decides to exercise the call option at the end of month, what will be the payoffs?

The payoffs are given in the diagram below

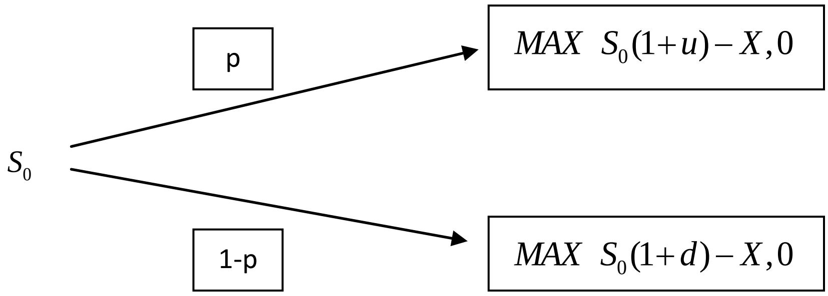

Figure 2.

Now, the expected payoff using the probabilities of up state and down state. From the above diagram, the expected value of payoff is

$$V_N = p*MAX\ \ S_0(1+u)-X,0\ +(1-p)*MAX\ \ S_0(1+d)-X,0 \qquad (7.4)$$

Once the expected value of the payoff is calculated, this expected value of payoff has to be discounted by risk free rate to get the arbitrage free price of call option. Use continuous discounting for discounting the expected value of the payoff.

In some questions, the probability of up state is not given. In such a case, probability of up state can be calculated with the formula

$$p = \frac{e^{rt} - D}{U - D} \qquad (7.5)$$

- *p = up state probability*
- *r = risk free rate*
- *d = Down state factor*
- *u = Up state factor*

Using the above the model building process, similar model can be build for multi period options and also for put options.

7.2.2.Binomial Option Pricing Model Advantages

- Binomial option pricing models are mathematically simple to use.
- Binomial option pricing model is useful for valuing American options in which the option owner has the right to exercise the option any time up till expiration.
- Binomial option model is also useful for pricing Bermudan options which can be exercised at various points during the life of the option.

7.2.3.Binomial Option Pricing Model Limitations

One major limitation of the binomial option pricing model is its slow speed and complexity. Complexity of computation is increased twofold in multi -period binomial option pricing model.

7.3. 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. (Chewlow, 1998)

Monte Carlo methods are used to handle both probabilistic and deterministic problems according to whether or not they are directly concerned with the behavior and outcome of a random process. In the case of a probabilistic problem a simple Monte Carlo approach is to observe random numbers, chosen in such a way that they directly simulate the physical random processes of the original problem, and to infer the desired solution from the behavior of these random numbers.

Monte Carlo simulation has wide application in performing risk analysis by building models of possible results by substituting a range of values (a probability distribution) for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete. Monte Carlo simulation produces distributions of possible outcome values. By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a realistic way of describing uncertainty in variables of a risk analysis.

Every Monte Carlo calculation requires repeated sampling of random events or random variables which in some way represent or define phenomena of interest. This repeated sampling is a way of simulating the behavior of the phenomena. In this way the sample or simulation can be used to make approximations of properties of interest.
Assume that some phenomena or process can be modeled or defined by a probability distribution f(x). The question arises of what is meant by “sampling”? A sampling procedure is an algorithm that can produce a sequence of values which can be considered to have been taken from the probability distribution f(x) which describes the process. The sequences of values produced are random variables. Then the question arises of how such values are indeed “random”? In practice sources of truly “random” numbers are rare and do not produce the volume of numbers required for practical purposes. The solution is to use pseudorandom numbers. Pseudorandom numbers are a sequence of numbers on the range (0,1) which can be easily generated by a computer algorithm and satisfactorily mimic the behavior of true randomness. These numbers can be considered to have been taken from a standard uniform distribution and so are uniform random variables. It is from a supply of these pseudorandom numbers that random variables from probability distributions can be sampled.

There are several applications of Monte Carlo simulation in financial settings. Methods are used to simulate various sources of uncertainty that affect the value of a financial instrument, a portfolio or an investment, and then to calculate a representative value given these possible underlying inputs.

In Corporate Finance a company often needs to value a project, which for example may involve an initial outlay with future expected profits. If these future profits can be estimated accurately then the firm can determine whether these profits will outweigh the costs and can then decide whether to proceed with the project or not. The factors affecting the future profits could consist of many variables, including but not limited to interest rate fluctuations, currency exchange rate changes, macro-economic factors, labour costs, environmental issues or advancements in technology. Since each one of these factors can be multi-dimensional there could be a very large amount of parameters to be estimated, each having its own distribution. Therefore MCMC methods can be implemented.

Stock options change in value depending on the price of an underlying stock, which itself can be affected by a very large number of factors. Simulation can be used to generate thousands of possible (but random) price paths in order to estimate the future value of an option. This can then allow a price to be assigned to the option at the current time point. The section on methods for option pricing contains more detail on this subject.

Portfolio Evaluation involves estimating the value of a collection of financial instruments such as stocks or bonds to determine the wealth to be gained. Monte Carlo methods can be used to simulate the correlated behavior of the components of the portfolio over time in order to assess how the portfolio is affected by certain price level changes in order to estimate the value of the portfolio.

Monte Carlo methods provide flexibility and can handle multiple sources of uncertainty however the techniques are not always appropriate. In general such methods are likely to be preferable when there exist several sources of uncertainty such as in the above cases.

8.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.
The option price is calculated with the formulas that are shown below.

$$C_{0,j} = \exp(-\int_0^T r_u du) C_{T,j} \tag{8.1}$$

It simplifies to;

$$C_{0,j} = \exp(-rT) C_{T,j} \tag{8.2}$$

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;

$$\hat{C}_0 = \frac{1}{M} \sum_{j=1}^{M} C_{0,j} \tag{8.3}$$

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

$$SE(\hat{C}_0) = \frac{SD(C_{0,j})}{\sqrt{M}} \tag{8.4}$$

$$SD(C_{0,j}) = \sqrt{\frac{1}{M-1} \sum_{j=1}^{M} (C_{0,j} - \hat{C}_0)^2} \tag{8.5}$$

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*,

$$dS_t = (r - \delta)S_t dt + \sigma S_t dz_t \tag{8.6}$$

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.

Suppose x_t=ln(S_t), then we have

$$dx_t = \nu dt + \sigma dz_t \tag{8.7}$$

$$\nu = r = -\delta = -\frac{1}{2}\sigma = \tag{8.8}$$

Equations (11) and (12) can be transformed into

$$\Delta x = \upsilon \Delta t + \sigma \Delta z \tag{8.9}$$

$$x_{t+\Delta t} = x_t + \upsilon \Delta t + \sigma(z_{t+\Delta t} - z_t) \tag{8.10}$$

In terms of the asset price *S* we have;

$$S_{t+\Delta t} = S_t \exp(\upsilon \Delta t + \sigma(z_{t+\Delta t} - z_t)) \tag{8.11}$$

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

$$s_{t_i} = \exp(x_{t_i}) \tag{8.12}$$

$$SE = \frac{SD}{\sqrt{M}} \tag{8.13}$$

$$C_0 = \exp(-rT)\frac{1}{M}\sum_{j=1}^{M}\max(0, S_{T,j} - K) \tag{8.14}$$

9.COMPUTATIONS

In this part, we will see the calculations of the investment options. Scenarios are given below;

The first one; 9 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. İn the second factory 2 machines will be sold to other firms due to facility capacity. The second one; 8 old injection machines clamping force is under 1000 tons, will be sold to other companies. 4 old injection machines will be sent to subcontractor firms. Subcontractor firms will continue production with these machines for us.

The third one; 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. Below the variable list is given.

Table 4. Variable List

S	K	T	M	N	r	σ	δ
Present Value	Cost to acquire assets	Time	Number of simulation	Time step	Interest rate	Standard deviation	Enflation rate

Firstly costs to acquire asset and present values are calculated for each option. And then with other variables the option values are calculated. Below each option value is given.

Table 5. Values of variables and Options

	S	K	T	M	N	r	σ	δ	C_0 (Option Value)
Option 1	6376800	7906000	1	1000	10	0,067	0,2	0,03	264,91 TL
Option 2	7153600	7904000	1	1000	10	0,067	0,2	0,03	1.189,04 TL
Option 3	7242000	7906000	1	1000	10	0,067	0,2	0,03	4.996,94 TL

The calculations for the third option;

K= Cost of 14 new injection machines + Logistic cost of 3 old injection machines

Cost of 14 new injection machines = 7.900.000 TL
Logistic cost of 3 old injection machines = 6.000 TL

K= 7.906.000 TL

S= Selling 6 old injection machine on main factory + Selling 2 old machine on the second factory + Annual profit of 3 old injection machines on the second factory + Annual profit of 3 old injection machines that are sent to subcontractor firms

Selling 6 old injection machine on main factory= 3.000.000 TL
Selling 2 old machine on the second factory= 300.000TL
Annual profit of 3 old injection machines on the second factory = 2.365.200 TL
(3x365x1440x1,5=2.365.200)
(3 machines-365 days-1440 part-1,5 Lira)
Annual profit of 3 old injection machines that are sent to subcontractor firms = 1.576.800 TL
(3x365x1440x1=1.576.800)
(3 machines-365 days-1440 part-1 Lira)

S=7.242.000 TL
After the calculation of S and K, Call value is calculated.

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

$$C_0 = 4996{,}94\ TL$$

The call value of the third option is the best scenario. For this reason we chose the third scenario instead of the first and second.

10.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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APPENDIX A

CODE FOR THE APPLICATION:

Monte Carlo code for Visual basic;

```
Sub MonteCarlo()
  Dim K, T, S, sig, r, div, N, M As Double
   K = Range("B2")
   T = Range("C2")
   S = Range("D2")
   sig = Range("E2")
   r = Range("F2")
   div = Range("G2")
   N = Range("H2")
   M = Range("I2")

    Dim dt As Double
    dt = T / N

    Dim nudt As Double
```

```
nudt = (r - div - 0.5 * sig ^ 2) * dt

Dim sigsdt As Double
sigsdt = sig * Sqr(dt)

Dim lnS As Double
lnS = Application.WorksheetFunction.Ln(S)

Dim sum_CT As Double
Dim sum_CT2 As Double

sum_CT = 0
sum_CT2 = 0

Dim myarray As Variant
myarray = Range("B5:K105").Value

Dim j, i, count As Integer

count = 1

  For j = 0 To M Step 1
```

```
  Dim lnSt As Double
  lnSt = lnS

  For i = 0 To N Step 1

  lnSt = lnSt + nudt + sigsdt * myarray(count, 1)
  If count < UBound(myarray) Then

  count = count + 1
  End If

  Next i

  Dim ST, CT As Double

  ST = Exp(lnSt)
  CT = WorksheetFunction.Max(0, ST - K)

  sum_CT = sum_CT + CT
  sum_CT2 = sum_CT2 + CT * CT
Next j
```

```
    Dim call_value, SD, SE, variable As Double


    call_value = sum_CT / M * Exp(-r * T)


    variable = (sum_CT2 - sum_CT * sum_CT / M) * Exp(-2 * r * T) / (M - 1)


    SD = Sqr((sum_CT2 - sum_CT * sum_CT / M) * Exp(-2 * r * T) / (M - 1))

    SE = SD / Sqr(M)


    Range("K2").Value = call_value

    Range("L2").Value = sum_CT

    Range("M2").Value = sum_CT2

    Range("N2").Value = SD

    Range("O2").Value = SE


End Sub

Sub MonteCarlo2()

End Sub
```

APPENDIX B

1000 iteration value of e ;

e	0,19327	-0,48572	-0,77267	0,185799	0,768784	0,980927	0,456252	-0,24064	-0,93159	0,49877398
	-0,56988	0,333255	-0,55126	-0,56284	0,550317	0,814893	0,838363	-0,25915	-0,87042	0,9199312
	-0,57394	0,294774	0,743934	0,640187	-0,65932	0,925358	0,30753	-0,53952	0,891168	-0,57682094
	-0,35995	0,100278	-0,8794	-0,99093	0,295423	-0,78889	0,691698	0,286068	0,074217	-0,87535042
	0,653728	-0,13864	0,559038	-0,7078	-0,01797	0,803686	-0,37017	-0,09025	0,922152	-0,24124367
	0,204903	-0,58115	0,798137	0,773405	-0,63659	-0,55154	-0,48677	0,321469	0,280949	-0,23444859
	-0,25093	0,95002	-0,56442	0,914722	-0,45529	-0,8449	-0,49542	-0,47286	0,228392	-0,37783086
	-0,77043	-0,68094	0,859514	-0,56693	-0,67539	0,709489	-0,35646	-0,3417	-0,47211	0,85620115
	0,792753	0,792128	0,051737	0,629256	0,126896	-0,1294	-0,96671	-0,11676	0,905257	-0,50129143
	-0,36742	0,634232	-0,80556	-0,28042	-0,16438	-0,09843	0,801657	0,191373	0,678852	0,20241263
	0,76482	-0,36442	-0,01622	0,809144	0,945083	-0,39357	-0,51911	0,150349	0,092667	-0,96601685
	0,10625	-0,42185	-0,16173	-0,12803	0,81541	-0,45335	0,418101	0,360749	-0,99268	-0,54893047
	-0,8826	-0,45686	-0,7633	-0,71404	-0,22384	-0,30105	-0,37937	0,821229	-0,69109	0,1655835
	-0,55509	-0,24963	0,687298	0,201578	-0,682	0,17836	-0,89396	0,722946	-0,61951	0,57374577
	-0,95211	0,204505	-0,96471	-0,90839	-0,29983	0,820661	0,694483	0,960352	-0,45434	0,5863027
	0,06772	0,756894	-0,75002	-0,87537	0,563748	0,549353	-0,9369	-0,34613	0,973364	-0,61259633
	-0,56101	-0,28457	0,132523	0,091013	0,485661	0,481879	-0,82853	0,096115	-0,61384	-0,18580274
	0,071846	-0,94415	0,238278	-0,49602	-0,26596	0,208714	-0,02706	0,659906	0,165953	-0,65772198
	0,184773	-0,863	0,100057	0,226078	0,260305	0,790637	0,370332	-0,43384	-0,01802	0,69665712
	0,762634	0,313614	0,033568	0,833077	-0,08711	-0,31663	-0,75618	-0,66814	0,280807	0,62128054
	-0,05334	0,134987	0,931577	-0,541	-0,49472	0,60332	0,211118	-0,13307	0,83067	0,06152436
	-0,53524	0,553552	-0,30479	-0,18735	0,804815	0,329159	-0,42673	-0,6591	-0,386	0,4998462
	-0,98524	0,429565	-0,60356	0,310258	0,144591	0,215275	-0,92105	-0,45221	-0,39198	0,0964402
	0,512853	0,956052	-0,7494	0,12337	-0,75923	-0,35998	-0,98473	-0,78311	0,893488	0,69543793
	-0,29942	-0,96586	-0,74411	-0,98812	-0,03963	0,263151	0,520605	-0,82344	0,573726	0,20628613
	0,70006	0,598352	0,598834	0,5795	0,762337	-0,02679	0,993167	0,274294	0,328308	-0,25754075
	-0,30045	-0,73462	-0,08311	0,299741	-0,89284	-0,07604	-0,02434	-0,97272	-0,33865	-0,22691169
	-0,15599	-0,9993	-0,37912	-0,68336	0,054894	-0,34727	-0,53028	-0,21038	0,027979	-0,358306
	0,917723	-0,97724	0,595223	0,314241	0,313168	-0,10491	-0,84756	0,593415	0,621441	0,56891636
	-0,91472	-0,55169	-0,82471	0,833664	0,925428	0,425547	-0,30354	0,074403	0,967469	0,75920225
	-0,8488	-0,05398	-0,28375	-0,23615	-0,63905	0,230889	0,876217	0,081531	0,302939	-0,93109675
	-0,18903	-0,11326	-0,30867	-0,18574	-0,1846	0,047734	0,154325	-0,52013	-0,93617	-0,67182814
	0,925717	0,655744	-0,24344	0,54704	0,680808	-0,19592	-0,66029	0,336295	0,896717	-0,81692834
	0,819504	-0,07129	-0,70833	0,982529	-0,51305	-0,89999	-0,45934	-0,26183	0,618029	-0,52713099
	0,544817	0,689131	0,86607	0,796078	0,066463	0,03572	-0,24235	-0,1613	-0,53022	-0,73109818
	-0,16879	0,141724	-0,25537	0,978774	0,24139	0,254016	0,88798	0,970229	0,220016	0,03392
	0,693039	-0,45351	0,028768	-0,84899	0,804872	0,787467	-0,11403	-0,7816	0,649663	0,92246334
	0,843514	0,947752	-0,34141	0,149867	-0,80826	-0,61509	-0,37041	-0,70877	-0,49137	0,41037913
	-0,09061	-0,08586	-0,97618	0,129026	-0,97387	-0,9495	0,315777	0,594768	-0,25984	0,3221324
	0,233628	0,656721	0,191708	-0,37882	-0,91942	0,395196	-0,44887	0,636417	-0,44455	0,29602221
	0,286549	0,080961	-0,22593	0,710735	-0,89297	0,918102	-0,07121	-0,34497	0,609308	0,75490675
	-0,19187	0,44491	0,36137	0,424891	0,969319	-0,8256	-0,26062	0,458184	-0,32055	-0,20770014
	0,357016	-0,31293	0,21429	0,716036	-0,08852	-0,32338	0,769642	0,064775	0,048985	0,82321658
	-0,26432	-0,14189	-0,19908	-0,73599	0,017583	-0,5309	-0,51821	0,425585	-0,26067	-0,20887642
	0,859569	-0,39998	-0,61001	-0,93274	-0,02508	-0,3229	-0,18979	0,73487	0,27189	-0,91432668
	-0,73206	0,631918	-0,76934	0,851641	-0,10981	-0,69983	0,213182	-0,12061	0,42458	-0,54286351
	0,455854	0,866016	-0,81572	-0,57272	0,434456	-0,6852	0,403835	0,270695	-0,42118	0,1123779
	-0,41698	-0,61767	-0,34235	0,923017	0,593795	-0,8703	-0,95072	-0,43466	-0,95244	0,04122099
	0,383488	0,598204	0,553128	-0,60379	-0,61979	0,629613	-0,71743	-0,53516	0,044824	0,61044942
	-0,4112	-0,93069	-0,90637	-0,85023	0,497005	-0,372	0,158735	0,164413	0,841348	-0,81133029
	0,818505	-0,82306	0,539632	0,598378	-0,69813	0,657685	0,799551	-0,82293	0,056609	-0,48137525
	0,560897	-0,40596	-0,80714	0,154101	-0,31341	0,926307	-0,12272	-0,54769	0,536598	-0,14068841
	-0,78335	0,335543	-0,51825	0,934672	-0,01195	0,719671	0,425577	-0,89826	0,127055	0,8885276
	0,195664	0,824371	-0,71867	0,743149	-0,311	-0,06181	-0,39448	0,350259	-0,50467	-0,66570394
	-0,25596	-0,73732	-0,20809	0,849638	0,767118	-0,10477	0,733208	-0,50834	0,052095	0,32730825
	-0,59104	-0,19569	0,639299	-0,19936	-0,737	-0,27225	0,818359	-0,65892	0,924308	-0,07669964
	0,310545	-0,62367	0,234072	0,380361	-0,82251	0,627036	-0,83189	-0,95808	0,024388	-0,15055711
	-0,47206	-0,17397	-0,48859	-0,78438	-0,12417	0,951114	0,808782	-0,95207	-0,64636	0,05946579
	0,891691	-0,82398	0,285363	0,084577	0,737347	-0,04776	-0,97327	-0,34409	0,533601	0,21135021
	-0,96895	0,197878	0,707485	-0,29744	0,512105	0,134943	-0,41263	0,17992	0,828623	0,3260547

0,62936	-0,8881	-0,71235	0,411206	0,546023	0,441541	-0,71452	-0,04236	-0,49134	0,60950711
0,672689	0,23131	0,23292	-0,75122	0,810912	-0,52328	0,863291	-0,68459	0,642626	0,62386553
-0,50866	-0,61305	-0,26597	0,833581	0,992348	-0,22721	-0,46445	-0,39964	-0,94218	-0,7363316
0,930813	-0,21027	-0,41273	-0,67754	-0,36707	0,86772	-0,07895	-0,21854	0,51552	0,94487466
-0,89828	0,824186	0,343111	0,133951	-0,3836	0,529905	-0,50797	0,277623	-0,05861	0,26105737
0,164351	0,510115	-0,78521	0,708032	0,801879	-0,93815	0,016546	-0,6103	0,906048	-0,2671626
0,920785	-0,97194	0,621517	0,370864	0,467837	0,74574	0,533979	-0,21075	0,952137	-0,35482896
0,531992	0,96651	-0,90583	0,223413	0,237866	0,909615	-0,48256	0,774805	0,757588	-0,32537483
-0,69809	-0,37082	0,757699	-0,85879	-0,60204	0,7226	0,599595	-0,1359	0,282917	0,44248178
0,474081	-0,90457	-0,95428	0,423722	-0,69919	-0,79015	-0,93867	-0,12673	0,331886	0,86622264
-0,08668	0,073047	0,431422	-0,08019	-0,4475	-0,0739	-0,56804	0,002918	0,754356	-0,07862779
0,091154	-0,74162	-0,31656	0,224451	-0,77878	0,559401	-0,20209	0,733574	-0,64737	0,97465464
0,625262	-0,41873	-0,88661	0,273567	-0,22037	0,541211	0,145019	0,893655	0,999107	0,16942173
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-0,8728	-0,57493	-0,38985	-0,19451	-0,8916	-0,38672	-0,28839	-0,70224	0,906192	0,59710932
-0,12683	0,898895	0,967631	0,397605	-0,19504	0,505583	-0,25119	-0,80914	0,550758	-0,17271563
0,237932	0,543134	0,708316	0,389019	0,944541	0,242538	-0,89089	-0,9134	0,527046	-0,36323125
0,232615	-0,26313	-0,16161	0,416481	0,357765	0,561316	-0,55017	0,986075	-0,24164	0,36983419
0,042991	-0,3271	0,647442	0,295655	-0,18291	0,929963	0,646016	0,070558	-0,20654	-0,47019809
-0,28841	0,402399	-0,94639	-0,14238	0,011819	0,346535	0,451897	-0,39534	0,078175	-0,38295083
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0,392006	0,652193	-0,36544	0,630494	0,785658	-0,64403	-0,53592	0,074545	0,241225	-0,42174422
-0,2255	0,421396	-0,52666	0,658065	0,166744	-0,79129	-0,33966	-0,90347	-0,26676	-0,31668145
-0,27023	-0,78682	-0,35867	0,997612	0,415641	-0,12093	-0,30468	-0,9404	0,90353	-0,99549755
-0,16533	0,885436	-0,53395	-0,40184	0,193016	0,118575	-0,07527	-0,78887	0,977002	0,60669084
-0,48668	0,255732	-0,38998	0,293042	-0,62049	-0,09588	-0,51626	0,049678	0,679361	-0,97910938
-0,59238	-0,56361	0,764627	-0,69952	-0,80974	0,953292	0,608611	-0,23661	0,122486	0,21410133
0,040975	0,435828	0,719782	0,971922	0,618114	0,010793	-0,81401	0,902669	0,087109	0,37859097
-0,87135	-0,8272	0,848034	0,361523	-0,92796	-0,8303	-0,50178	0,454478	0,025431	0,86604033
-0,1407	-0,15757	0,533576	-0,57544	-0,52203	0,581948	-0,04126	-0,72967	0,469175	-0,34279454
0,217847	-0,43484	0,141023	-0,65715	-0,67868	0,386203	-0,45408	0,586924	0,590193	-0,30295382
0,638386	0,001175	0,552596	0,915739	0,646921	-0,32802	-0,9674	-0,20387	0,915896	0,806635
-0,85523	-0,7289	0,118194	-0,82054	-0,69215	0,982342	-0,32159	-0,20637	0,218087	-0,61883322
-0,69673	-0,07454	-0,63128	-0,50329	-0,8924	-0,69215	0,025705	-0,55046	-0,72613	0,90087733
-0,80783	-0,22103	-0,78494	-0,9874	0,855924	-0,73492	-0,47066	0,395027	0,291493	-0,6762568
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-0,68962	-0,81505	-0,79544	-0,35632	0,888843	-0,85254	-0,32974	0,979508	0,077664	-0,32065229

BIOGRAPHICAL SKETCH

Burak Kayserilioğlu was born in Istanbul on March 22, 1987. He has studied at Maltepe Anatolian High School where he graduated in 2005. He started his undergraduate studies at Mechanical Engineering Department of Yildiz Technical University in 2005. He has studied as an exchange student at Vienna University of Technology in 2009.

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