Int. J. Nonlinear Anal. Appl. 13 (2022) 2, 3017–3029
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2022.26950.3459

Designing an optimal model for choosing real options in knowledge-based companies (content analysis approach and Black-Scholes model)

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(Communicated by Ehsan Kozegar)

Abstract

Real option is a systematic approach in which economic modeling can be done using financial theories, economic analysis, operations research, decision theory, and statistics. The aim of this study is to design an optimal model for selecting real options in knowledge-based companies. This research is conducted with a mixed approach in two parts: qualitative and quantitative. In the qualitative section, by interviewing tools and qualitative content analysis method, the components of real option selection in knowledge-based companies are identified. The statistical population in this section includes university specialists and experts, managers of knowledge-based companies and competent individuals with executive positions in these companies who have executive backgrounds at decision-making levels. The sample size is obtained by purposive sampling equal to 12 people. Based on the results of the qualitative section, 11 main components and 103 sub-components are identified to select real options in knowledge-based companies. After identifying the components of real options' valuation in knowledge-based companies, the obtained qualitative model is tested by the Black-Scholes method. To this end, the qualitative section variables are converted to computable data for knowledge-based companies and then, the relevant statistical data are collected for 50 knowledge-based companies. Quantitative section variables include operating profit, depreciation, capital expenditures, working capital and, finally, the free cash flow of knowledge-based companies. The results show that the Black-Scholes method has more valuation than the traditional method.

Keywords: real option, knowledge-based companies, Black-Scholes model
2020 MSC: 34A60

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Received: January 2022 *Accepted:* April 2022

1 Introduction

Today, knowledge-based businesses play an important, vital and undeniable role in the development of countries, and investing in these businesses leads to a knowledge-based economy. From the perspective of governments, knowledge-based companies are recognized as important sources of income and employment and ultimately an important force influencing economic development. Knowledge is considered as one of the most effective forces in economic and social developments and is considered as a public good; because knowledge can be shared with others without reduction and depreciation. At the same time, it is a unique feature of this public good that, unlike other physical goods (such as capital, material assets, and natural resources), its use does not diminish in quantity and it can be used many times. In this way, knowledge as a permanent resource is always available to businesses and by repeatedly participating in various production and service processes, increases competitive advantage and creates added value, which can lead to the expansion of social welfare, reduction of poverty and injustice, and promotion of the development process [23]. Upstream documents of Iran, including the communicative policies of Article 44 of the Constitution, the Fourth and Fifth Development Plans, as well as the 20-year vision document of Iran, all consider the field of knowledge-based economy as important and influential areas in the country and have put its development on agenda. Achieving these goals is the creation of knowledge-based companies, which are mainly guided by the presence of entrepreneurs who have core ideas. In fact, the driving force of technological advances is the creative ideas that are formed in the minds of innovators and inventors and are produced by the serious pursuit of entrepreneurs in the form of new business. In this regard, these companies and their scientific growth and technological development have been one of the focus of Iranian policymakers in recent years.

The goal of any for-profit business is to create wealth for owners and other stakeholders. The directors of large corporations, who manage the affairs of the company on behalf of the shareholders, pursue the goal of maximizing the value of the shares. In this regard, managers make and implement various decisions in the areas of investment, financing, profit sharing, current operations, control and supervision, etc. Studies by Fisher Black, Robert Merton [19], and Myron Scholes have introduced a standard model for pricing financial options. Pricing is one of the main topics in investment management. Improper pricing and the use of inappropriate and impractical methods in determining the value of assets leads to non-optimal allocation of capital and waste of capital resources [31]. Despite the high importance of pricing, due to the lack of financial options and consequently real trading options, little attention has been paid to the pricing of companies' stocks based on the real option approach in Iranian knowledge-based companies; therefore, it is very important to study this part of financial science with a new and different approach in knowledge-based companies. In knowledge-based companies that are in the early stages of their development, the study of applied and different methods of vision and the presentation of relatively new models and complementary to conventional and traditional methods, has a special necessity and priority. Therefore, the present study was conducted with the aim of designing an optimal model for selecting real options in knowledge-based companies (content analysis approach and Black-Scholes model).

2 Theoretical foundations and research background

The growth and development of any economy depends on investment at the macro, national, targeted and carefully planned level of each country. Knowledge-based companies are one of the most important economic sectors in Iran that are of special importance and finance other economic sectors. Accordingly, the optimal use of knowledge-based companies requires investment in this sector, and it is clear that investment requires the formation of capital and the use of financing tools [22].

When the real option is used in a project with capital budgeting, a method and model is needed for its evaluation. Depreciation of cash flow (DCF) or net present value (NPV) predicts future cash flows of the plan. The main problem with DCF is the lack of flexibility. In using this method, management is passive about new information. DCF is neutral about future aspect of the problems, including risk and the timing of the arrival of flows. As the uncertainty and flexibility of cash flows increases, so does the value of the option. The reason is the existence of an option that benefits from positive results and prevents negative results. So the higher the uncertainty, the more positive and negative results will be associated with uncertainty. As a result, positive and negative results will appear on a higher scale, and since we benefit from positive results in options and negative results have no effect; therefore, the higher the uncertainty, the higher the value of the option [12].

The Black-Scholes model [3] has been very popular since it was proposed; because it has accepted the asset pricing formula for option. However, some of its simplistic assumptions, such as the logarithm of the base price normality, which is used to achieve analytical portability, are not appropriate. This model cannot actually show the main features of asset returns such as skewness and kurtosis as shown by real market data. To avoid the large pricing biases caused by such oversimplification, much research has been shifted to more sophisticated models. A natural development is the generation of random variables of fluctuations or interest rates, such as the Heston [13] and Heston-CIR (2018) models [16].

Various financial market researchers have used the Black-Scholes model for real options. These studies include the studies of Cox et al. [6], Rendleman and Bartter [26], Rubinstein [27], Boyle [4], Hull and White [14], Scott [28], Naik [21], Amin and Ng [1], Duan [9] and Scott [29]. Researchers such as Macbeth and Merville [17], Dumas et al. [10] and Poon [25] introduced and modified the assumption of underlying asset instability in the Black-Scholes model.

Kobari [15] used the Black-Scholes pricing model to assess the impact of environmental policies on industrial greenhouse gas emissions. Szolgayova et al. [30] studied the technical cost of carbon preservation using the Black-Scholes model. Zhang et al. [34] used the modified Black-Scholes model to consider the impact of fluctuations and technology development on the value of a firm's copyright. Zhang et al. [35] used the Black-Scholes model to evaluate copyright and compared it with the results of the revenue method for promoting trade in the Chinese copyright market. Picozzi and West [24] proposed the real option equation as a Langwin fraction equation to observe memory effects in financial time series. Also, due to the complexity of the financial system, investors do not make a decision immediately after receiving financial information, but wait for the information to reach its threshold. This behavior can lead to traits such as "long memory" [33]. In addition, Andersen and Bollerslev [2] and Müller et al. [20] showed that there is dependence on high-frequency financial data.

A review of the literature and research background shows that so far no research has examined the optimal pattern of choosing the right option in knowledge-based companies, which shows the innovation of the present study.

3 Research methodology

The present research is applied in terms of its objective and is a type of mixed research (qualitative and quantitative). The qualitative part has been done by interview tools and qualitative content analysis methods with the help of MAXQDA software. The statistical population in this section included university specialists and experts, managers of knowledge-based companies and competent individuals with executive positions in these companies who have executive backgrounds at decision-making levels. The first step to calculate the sample size was defining the expert based on the exact specifications of the experts. A comprehensive definition of experts should be provided. Therefore, purposive sampling method is commonly used in qualitative research [8]. Therefore, in this study, purposive sampling method was used to select experts and the selection of experts continued until the theoretical saturation was reached. According to this issue, 12 people were selected as the statistical sample.

In the quantitative part, data related to components were collected in relation to knowledge-based companies. The statistical population in the quantitative part is knowledge-based companies in Iran, which number about 2000 companies. Sampling was performed by systematic removal method. Therefore, companies that had incomplete data or their fiscal year did not end on March 20 were excluded from the sample. Finally, 50 knowledge-based companies in the period 2009-2010 were selected as the statistical sample. After data collection, data analysis was performed by GARCH regression and Black Scholes model.

3.1 Black and Scholes model

One of the models in the discussion of option pricing is the Black Scholes model. The Black Scholes equation may seem like the right method for real option analysis because it is widely used and easy to use in valuing financial option. The Black-Scholes equation can be adjusted for the act of bad income when this income has a fixed rate as follows.The famous Black-Scholes equation is as follows:

$$C = N(d1)S0 - N(d2)Xexp(-rT) \tag{3.1}$$

$$D1 = [\ln \frac{S_0}{X} + (r + 0.5\sigma^2)]/\sigma\sqrt{T} \tag{3.2}$$

$$D2 = d1 - \sigma\sqrt{T}, \tag{3.3}$$

where c is equal to the value of the option, S_0 is equal to the present value of the main asset, X is equal to the investment cost at the agreed price, r is the risk-free rate of return, T is the expiration time, σ is the standard deviation of the future cash flow of the main asset, and $N(d1)$ and $N(d2)$ are the standard normal distribution values of $d1$ and $d2$, respectively (available as a function in Microsoft Excel).

The Black and Scholes equation is the easiest way to calculate the value of an option if it can be applied to your option problem. The input parameters T, X, r, and S_0 are simply detected, but $N(d1)$ and $N(d2)$ can be obtained from Excel. The standard deviation coefficient (σ), which indicates the uncertainty of the main asset, may be the most difficult to calculate compared to other input parameters. The features of the Black and Scholes model can be summarized as follows: 1) Black-Scholes assumes the distribution of the value of the underlying asset as a normal logarithm that may not be true of cash flows associated with real assets. 2) Black-Scholes also assumes a steady increase in the value of an asset through its fluctuations and does not take into account ups and downs and jumps. 3) Black-Scholes only allows a bargain price for an option that can change over the life of a real option. 4) While with the proper adjustment of the Black-Scholes approach some of these limitations can be overcome, but this makes a complex equation much more complex. 5) This relationship is true for financial option, and the dividend rate is the same as the ratio of shareholders' profit to the total profit.

In the method of real option theory, using the Black-Scholes model, the parameters of the model are estimated and analyzed by substituting in different scenarios. As the number of periods in the binomial tree model increases, the time interval between periods decreases to the point where time is assumed to be continuous. Along with this assumption, Black and Scholes argued that price follows a random process and should be considered as a random variable. In other words, the price distribution is normal.

Black and Scholes argued that momentary price changes follow a geometric Brownian motion:

$$\frac{ds}{s} = u.dt + \sigma.dz \tag{3.4}$$

In the above relation, u = average annual return; dt = time interval; σ is the standard deviation of annual returns, and dz = random variables.

Equation (3.4) states that price changes consist of two components: one component is the expected value of the return proportional to the time period, and a random component equal to the product of the standard deviation multiplied by a random variable, having a mean of zero and a variance equal to one.

The return of an asset in the discrete state is obtained from the relation $r = S_i - S_{i-1}/S_{i-1}$ and in the continuous state, it is obtained from $r = \ln(S_i - S_{i-1})$) (Where, r is the rate of return and S_i is the stock price at time i). Because the stock price has a normal distribution, then $\ln(S_i)$ follows the normal logarithm distribution.

If u and σ are considered as the mean and standard deviation of the annual return on asset S, then:

$$E(\ln S(T)) = \ln S. + \left(\mu - \frac{\sigma^2}{2}\right) T \tag{3.5}$$

$$Var(\ln S(T)) = \sigma^2 T \tag{3.6}$$

or

$$\ln S_T \sim \phi(\ln S. + \left(\mu - \frac{\sigma^2}{2}\right) T, \sigma\sqrt{T}) \tag{3.7}$$

the function $\phi(a, b)$ represents the normal distribution with a mean of a and standard deviation of b. Therefore, the following equation is a normal standard variable with a mean of 0 and standard deviation of 1.

$$Z = \frac{\ln S(T) - \ln S. + \left(\mu - \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}}. \tag{3.8}$$

Another fundamental assumption of Black and Scholes is the indifference of investors to risk. So all investors expect risk-free (r) investment in underlying assets. Therefore:

$$\ln S_T \sim \phi(\ln S. + \left(r - \frac{\sigma^2}{2}\right) T, \sigma\sqrt{T}) \tag{3.9}$$

$$Z = \frac{\ln S(T) - \ln S. + \left(r - \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}} \tag{3.10}$$

For an option at maturity, two cases are conceivable. If the market price is less than the agreed price, the option value is zero and does not apply; if the market price is higher than the agreed price, the option is applied and the cash inflow S and the cash outflow K are obtained.

$$C = \begin{cases} S - K & S \geq K \\ 0, & S < K \end{cases} \tag{3.11}$$

These two flows can be separated:

$$C_0^1 = \begin{cases} -K & \geq K \\ 0, & < K \end{cases} \qquad \text{Cash outflow after application} \tag{3.12}$$

$$C_0^2 = \begin{cases} S & S \geq K \\ 0, & S < K \end{cases} \qquad \text{Cash inflow after application} \tag{3.13}$$

If the variable d_2 is shown as equation (3.14),

$$d_2 = -\frac{\ln K - \ln S - \left(r - \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}} \tag{3.14}$$

Option is applied when $S \geq K$, which is equal to $Z \geq -d_2$. Therefore, the probability of option implementation is equal to the level below the diagram of the normal distribution function from $-\infty$ to d_2:

$$E(C_0^1) = -KP(S \geq K) = -KP(Z \geq -d_2) = KN(d_2) \tag{3.15}$$

Its current value is equal to:

$$C_0^1 = -Ke^{-rT} N(d_2) \tag{3.16}$$

If $A = \begin{cases} B & B \geq C \\ 0, & B < C \end{cases}$, such that A is a variable with standard normal distribution:

$$\ln A \sim \phi(m, s^2) \tag{3.17}$$

Also, if m and s^2 are distribution mean and variance, respectively, then:

$$E(A) = e^{\left(m + \frac{s^2}{2}\right)} N(S - D) \tag{3.18}$$

In the above equation:

$$D = \frac{\ln C - m}{s} \tag{3.19}$$

$$m + \frac{s^2}{2} = \ln B + \mu T \tag{3.20}$$

$$D = \frac{\ln C - \ln B - \left(\mu - \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}} \tag{3.21}$$

$$s - D = \sigma\sqrt{T} + d_2 = d_1 \tag{3.22}$$

As was mentioned earlier:

$$C_0^2 = \begin{cases} S(T) & S(T) \geq K \\ 0, & S(T) < K \end{cases} \tag{3.23}$$

Then, the following equation holds true:

$$D = \frac{\ln K - \ln S - \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = -d_2 \tag{3.24}$$

By substituting equation (3.24) in equation (3.18), the expected value of the cash flow received as a result of the option application is obtained:

$$E(C_0^2) = e^{(\ln S + rT)}N(S - D) = Se^{rT}N(d_1) \tag{3.25}$$

$$(d_1 = \sigma\sqrt{T} + d_2) \tag{3.26}$$

Its current value is:

$$C_0^2 = SN(d_1) \tag{3.27}$$

By summing up equation (3.16) and (3.25), the value of an option is equal to:

$$C = SN(d_1) - Ke^{-rT}N(d_2) \tag{3.28}$$

In the Black-Scholes model, the expected return on assets is not directly considered. However, the price of the pledged asset itself is a function of the expected return, and the current price of the asset implicitly reflects the expected return. As mentioned, the Black-Scholes model introduced in this section is an advanced model for pricing European options as well as US options for unpaid assets, but one of the problems is that it is not appropriate for an asset including payment during the option period. If there is an option on a particular asset that has payment during the option, such as a stock with dividends, the Black-Scholes model is adjusted to value the option to buy that share. In this case, the current value of future payments should be deducted from the stock price and the result should be entered as a new price in the model:

Payment of a fixed amount on a discrete basis: $S^* = S - \sum_{t=1}^{T} \frac{Div}{(1+r)^t}$

Payment of a fixed amount on a regular basis: $S^* = S - De^{-rT}$

4 Findings

4.1 Findings of the qualitative section

First, the characteristics of 12 experts including age, gender, level of education and work experience are presented in Table 1. From the 12 interviewees, 3 were female and 9 were male; and all of them are over 34 years old and have more than 5 years of work experience. Also, four people have a master's degree and eight people have a doctorate. In the next section, qualitative content analysis is performed by three stages of open, axial and selective coding with the help of interviews with experts.

4.1.1 Open coding

In this study, first the content of all interviews was implemented and then their open coding was done by key point coding method. In this way, the data collected in the interviews were written in a Word file and then open codes were created by analyzing the existing writings [18]. Thus, a total of 103 codes were extracted from open coding.

4.1.2 Axial coding

Axial coding is the second stage of analysis in qualitative methods. The purpose of this stage is to establish the relationship between the classes produced in the open coding stage [7]. When establishing connections in the network, it is necessary to examine how these categories relate to each other. Finally, 11 main components and 103 sub-components were identified to select the real option in knowledge-based companies in accordance with Table (3). The main components are: 1) setting goals; 2) goal setting constraints; 3) definition of real option; 4) types of real

Table 1: Application Domain Of Face System

No.	Age	Gender	Education	Work experience
1	45	Male	Ph.D.	15 years
2	46	Male	Ph.D.	15 years
3	43	Male	MA	14 years
4	44	Male	MA	10 years
5	41	Male	Ph.D.	10 years
6	39	Male	Ph.D.	7 years
7	38	Female	Ph.D.	8 years
8	37	Male	Ph.D.	6 years
9	35	Female	Ph.D.	6 years
10	50	Male	MA	20 years
11	34	Female	Ph.D.	5 years
12	51	Male	MA	20 years

option; 5) flexibility in the type of option; 6) effective factors in real option; 7) appropriate process of designing real option; 8) challenges in valuing real option; 9) evaluation of real options; 10) macro government policy; and 11) components of real option.

4.1.3 Selective coding

Selective coding is the process of integrating and improving categories [36]. The main category should have the following characteristics: First, it should be obtained by codes that are more centralized in the axial coding stage; second, it should show the highest frequency in the coding process. Third, all communications with categories should be done spontaneously [11]. The results of selective coding and the qualitative model of selecting the real option in knowledge-based companies are shown by Figure 1.

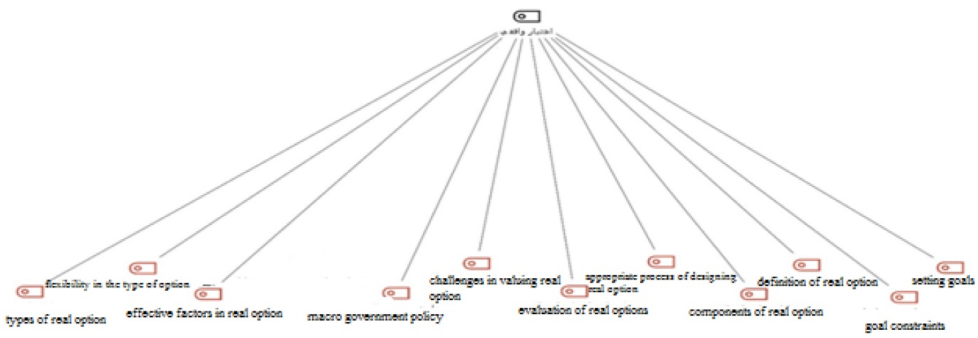

Figure 1: Maxqda software output for the main components

4.2 Quantitative section findings

After identifying the components of the real option selection model in knowledge-based companies, the components related to real option have been quantitatively tested by the Black-Scholes model. The outputs of the qualitative section have been adjusted to enter the quantitative section as follows: 1) Given that there are several models for real option pricing, the Black-Scholes model has been used for pricing. 2) For Black Scholes model inputs, to calculate the present value of cash inflows from the company's free cash flow, funds that remain fixed in the company after paying all operating expenses and performing necessary operating expenses such as working capital and assets, and will be payable to capital suppliers (shareholders and lenders) are used that is shown with FCFF. 3) The GARCH model has been used for the variance modeling calculations used in the Black and Scholes model and we have performed the correct measurement estimation through the maximum likelihood function. 4) First, information about the project of knowledge-based companies is obtained. In this regard, to identify the real options in these companies, the valuation of projects has been first examined. Then, according to the value obtained for the projects, we have identified input factors for the calculation of real option. Also, 50 stock exchange knowledge-based companies in the period of 2019-2020 were selected as a statistical sample and their data were averaged. The input variables of Black and Scholes model for real option in knowledge-based companies are as follows:

Present value of cash inflows

Cash flow-based models are the most important and main approach to corporate valuation. In this method, the future ability of the company to create cash flow is evaluated and there is a look at the future of the company; therefore, it is necessary to predict the macroeconomic variables of economy, industry and company in order to estimate the company's cash flows. Finally, cash flows are discounted to achieve the present value of the stock or company. The company's free cash flow is the funds that remain fixed in the company after paying all operating expenses and performing necessary operating expenses such as working capital and assets, and will be payable to capital suppliers (shareholders and lenders) that is shown with FCFF; given that funds payable to shareholders also need to be reported separately, by deducting funds payable to lenders, shareholders' cash flow will be calculated as indicated by FCFE. To calculate the FCFE, the FCFF must first be calculated for future years, then the debts will be deducted from the total current value of the FCFF and other necessary adjustments will be made according to the FCFE formula. These calculations are shown in Table 2.

Table 2: How to obtain free cash flow of the company

	Operating profit
+	Depreciation
-	Capital expenses
-	Investment in working capital
=	Free cash flow of knowledge-based companies

According to the free cash flow formula of the company, the free cash flows obtained from the real option of the project are 2494255 million Rials.

Variability of the underlying asset

Modeling price fluctuations is the application of most time series econometric tools to model the conditional mean of random variables; while most economic theories are designed to work with conditional variance or fluctuations in a process. Fluctuations in financial markets have led researchers to develop practical models for measuring and predicting fluctuations in stock returns and stock market price indices. An important category of these models are GARCH models. In the study of time series data, the assumption of fixed over time is always considered, but in practice, the variance is not constant in different periods. To solve the problem of unstable variance, either the data must be converted to achieve homoscedasticity or models that accept heteroscedasticity must be used. A well-known family of these models is the family of conditional heteroscedasticity models, which are known to be very useful in various fields such as economics, physics, electrical circuit theories, and so on. These models are called conditional autoregressive models with variable dispersion. GARCH-bound autoregressive models can be used to estimate the variance of cash flows. These models are used to analyze financial data. This method can also be used to estimate cash flow fluctuations. GARCH models are mainly used in the analysis of financial time series data as well as in determining conditional variance and fluctuations. GARCH models are designed to reduce existing nonlinear and random errors and increase predictive power for real option trading. Conditional variance between returns can be used to estimate the variance of the portfolio resulting from real options. It should be noted that the data were entered into Eviews software on a monthly basis to estimate the GARCH model.

First, the homoscedasticity test is used to prove the use of the GARCH method. If the error terms in the model have variance heterogeneity, the GARCH model can be estimated with confidence. The null hypothesis of this test is homogeneity of variance. Therefore, if the probability level is less than 5%, the null hypothesis is accepted and the model has heteroscedasticity. According to Table 3, considering that the probability level of the test statistic is less than 0.05, the results of the ARCH-LM test at the 5% probability level indicate the existence of variance heterogeneity in the model residues. Therefore, the GARCH method can be used to estimate the model with confidence.

Table 3: ARCH-LM test results

F statistics	**Prob. Level**	**Results**
4.186	0.04	Heteroscedasticity

To accurately determine the GARCH model, different GARCH patterns with different degrees must be tested.

Whichever model has the lower Akaike and Schwarz criteria is a better model. The test results of different patterns of GARCH model are described in Table 4. According to Akaike and Schwarz criteria, the best GARCH regression model is the GARCH(1,1) model.

Table 4: GARCH model estimation results

Criteria	**GARCH(1,1)**	**GARCH(2,1)**	**GARCH(0,1)**
Akaike	20.757	21.560	21.734
Schwarz	21.004	21.857	21.932

Finally, regression is estimated based on the selection of the best model, which is GARCH(1,1). Since we need the conditional variance of cash flows to test the model, the output of the conditional variance is presented in this section as Figure 2. According to the figure, the average conditional standard deviation of cash flow returns during the study period is 2.100%. This number is used to calculate the Black-Scholes model.

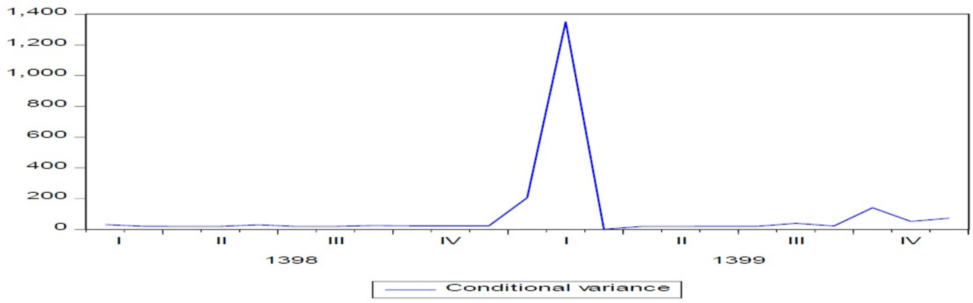

Figure 2: Conditional variance of cash flow returns

Options' life

For financial options, the time to maturity is clear (stated in the contract), but in many cases, it is not true for a real option. Often you do not know exactly how long it takes to exercise option, so it takes a year. Therefore, in this study, for a more accurate evaluation, data from the two years 2019 and 2020 are averaged.

Risk-free interest rates

The risk-free interest rate used in real options is usually based on the rate of return on US Treasury bonds, which is equivalent to bonds in Iran, but according to experts, only 5% of bonds are used in Iran; therefore, the conventional bank rate of 18% is considered as a risk-free interest rate.

Agreed price

Agreed price is the cost that is paid for the purchase or sale of basic real property that is equal to 1492262 million Rials according to Table 5. This cost is obtained by the average cost of buying or selling assets by knowledge-based companies in the period under study. In general, the cost is the cost required to acquire the project assets.

Table 5: Calculation of the cost of buying or selling basic real property in knowledge-based companies

Knowledge-based companies	**Cost of buying or selling basic real property**
Mean	1492262

Calculating real option

The valuation of the company's projects has been done and the free cash flows resulting from the implementation of the project are 2494255 million Rials. These projects will be done with investment costs of 1492262 million Rials. Considering that we have considered one year to exercise the option and obtain the standard deviation of the company's return using GARCH and the maximum likelihood function of 2.100%, we will obtain a value of 1023035 million Rials for real option calculation according to the Black-Scholes model.

$2494255 - 1492262 = 1001993$

$1001993 \times 0.021 = 21042$

$1001993 + 21042 = 1023035$

$1023035 - 1001993 = 21042$

According to the results, the value obtained from the Black-Scholes method is 21042 million Rials more than the traditional and conventional valuation, which shows that the Black-Scholes method results in more valuation than the traditional method.

Calculating the real transfer option

The calculation of the real transfer option is performed by the two methods of current value of cash inflows and project transfer price as follows.

Current value of cash inflows

In this section, the valuation of the company is obtained by free cash flow in accordance with Table 6. The value of the company is derived from the total market value divided by the free cash flow for knowledge-based companies. Accordingly, the value of the company for knowledge-based companies is 561258952. Also, cash and NPV of investments for knowledge-based companies were equal to 12023652. The sum of these two results in the market value of the equity of 573282604. Also, the number of shares issued in knowledge-based companies was equal to 3052132600. Therefore, the market value of each share is obtained by dividing the market value of equity by the number of issued shares, which is equal to 0.18783.

Table 6: Valuation of the company by free cash flow (calculation of the real value of each share)

Value criteria	**Company valuation**
Company value	561258952
Cash and investments	12023652
Market value of equity	573282604
Number of shares issued	3052132600
Market value per share	18783

Project transfer price

In order to calculate the project transfer price, considering that in the projects of knowledge-based companies, the project can be usually transferred after receiving a 30% profit after one year, the value of the transfer option is considered with the base prices according to table 7 and sensitivity analysis of the transfer price has been performed. It should be noted that the value of the transfer option has been calculated according to the minimum and maximum stock prices during the year.

Table 7: Sensitivity analysis of transfer option

	At least per share	**30% less than the value**	**The maximum price that zeroes the value of the option**	**Real value per share**	**30% more than the value**	**The maximum price per share**
Base price	9325	13148	21000	18783	24418	32521
Transfer option value	0.00	0.00	0.12	6.12	10236598	42098631

Finally, the optimal choice of the type of company option is done by sensitivity analysis based on the base price, the value of the transfer option, and the value of the development option in accordance with table 8. As can be seen, in case the share is not sold at its real value and is lower than its real value, the development option can be used best, but in case the maximum share price is for sale, the transfer option can be used.

5 Conclusion and Recommendations

Real option is a systematic approach in which economic modeling can be done using financial theories, economic analysis, operations research, decision theory, and statistics. Real option theory in a dynamic decision-making environment and uncertain business environments is an approach by which strategic decisions, investments, valuations

Table 8: Optimal choice of option type

	At least per share	**30% less than the value**	**The maximum price that zeroes the value of the option**	**Real value per share**	**30% more than the value**	**The maximum price per share**
Base price	9325	13148	21000	18783	24418	32521
Development option value	29520258	29520258	29520258	29520258	29520258	29520258
Transfer option value	0.00	0.00	0.12	6.12	10236598	42098631
Optimal option choice	29520258	29520258	29520258	29520258	29520258	42098631

and expenditures of economic plans and projects are evaluated. One of the basic assumptions of real option theory is that the management is rational and has sufficient authority in the relevant decisions, and in this regard, considers the merits and interests of shareholders and make every effort to maximize their wealth. Based on the provided explanations, the present study was conducted with the aim of designing an optimal model for selecting real options in knowledge-based companies. This research was conducted in two qualitative and quantitative parts.

In the qualitative section, open, axial, and selective coding was performed based on the qualitative content analysis of the interviews to implement real option selection model in knowledge-based companies. Based on the results, 11 main components and 103 sub-components were identified to select real option in knowledge-based companies. Therefore, in order to choose the right option in knowledge-based companies, the goals of choosing the right option must be identified and determined. Also, the limitations that exist in achieving the goals must be identified. These constraints generally include differing views, legal and financial constraints, non-simultaneous options, and so on. Real option must also be examined and identified in terms of types, definitions, components and factors affecting it. Real option is inherently property, that is, it is associated with ownership and flexibility, and since risks are so diverse, so must options be diverse. The design of a real option must have a proper process, its implementation methods and challenges must be clear and its evaluation must be thorough. Macro-government policies are also very important in this regard, so that items of government policies such as government restrictions, government laws, government instructions such as Article 44 of the Constitution, etc. affect the valuation of real option. The results obtained from the qualitative section are consistent with the studies of Wang et al. [32] and Chen et al. [5].

After identifying the valuation components of real option in knowledge-based companies, the obtained qualitative model was tested by the Black-Scholes method. In the Black-Scholes model, the qualitative section variables were converted into computable format for knowledge-based companies and then the relevant statistical data were collected for 50 knowledge-based companies. Quantitative sector variables included operating profit, depreciation, capital expenditures, working capital and, finally, the free cash flow of knowledge-based companies. The results showed that the Black-Scholes method results in more valuation than the traditional method. Also, in case the share is not sold at its real value and is lower than its real value, the option of developing is the best option that can be used, but in the case where the maximum share price is for sale, the option of transfer can be used. The results of this section are consistent in terms of higher valuation than the traditional model.

According to the obtained results, in order to be able to choose the real option more easily, it is necessary to provide the necessary executive contexts and ground by experts and managers. Because flexibility is important for valuing real options, knowledge-based companies are recommended to examine economic plans more closely and base managers' decisions on calculated valuations. Since setting goals and identifying relevant constraints is one of the factors affecting the valuation of real option, knowledge-based companies are recommended to identify goals and carefully examine limitations in achieving the goals before taking valuation actions. Because macro-government policies play a major role in valuation, knowledge-based companies are recommended to have the flexibility to adapt their policies to government. Considering the uncertainty in decisions and the flexibility of real option, it is recommended to fully identify project uncertainties and risks in transactions and management and the working team take actions to reduce the risks and dangers. Since inflation, fluctuations and economic cycles are important factors in choosing the right option, it is recommended to use capital assets to cover inflation. Flexibility in the type of option should be considered based on the ability and taste of management and the factors that lead to greater profitability should be considered. Managers and investors of knowledge-based companies are recommended to consider market conditions and thereby predict the future of the market for their valuations. Given that the real option has a greater valuation by the Black-Scholes model compared to the conventional model, knowledge-based companies are recommended to consider the fluctuations of free cash flow to value the real option. It is also suggested that in case the share is not sold at its real value and is lower than its real value, the development option should be used and in case the maximum share price is for sale, the transfer option should be used.

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