Int. J. Nonlinear Anal. Appl. 15 (2024) 8, 65–78
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2023.29175.4079

Identifying the components of real option to choose in knowledge enterprises

Farahnaz Jangoo[a], Mohsen Seighal[b,*], Hakimeh Niki Esfahlan[c], Younes Badavar Nahandi[a], Heydar Mohammadzadeh Salteh[d]

[a]*Department of Management, Economics and Accounting, Tabriz Branch, Islamic Azad University, Tabriz, Iran*

[b]*Department of Management and Accounting, Qazvin Branch, Islamic Azad university, Qazvin, Iran*

[c]*Department of Management, Hadishahr Branch, Islamic Azad university, Hadishahr, Iran*

[d]*Department of Accounting, Marand Branch, Islamic Azad university, Marand, Iran*

(Communicated by Ehsan Kozegar)

Abstract

In today's complex and developing world, making accurate and timely decisions is very important for both managers and investors. The progress in the financial field, the invention of new financial methods and tools and the introduction of various software packages indicate the fact that in developed and developing economies, relying on traditional decision-making methods doesn't meet the needs of investors due to market requirements and competition to catch the opportunities among investors, especially institutional investors active in the real sector of the economy. The real option is a systematic approach in which economic modelling can be done using financial theory, economic analysis, operations research, decision theory, and statistical science. The present study was conducted to identify the components of the real option to choose in knowledge enterprises. The research was done with a qualitative approach. In the qualitative section, the components of real options to choose from in knowledge enterprises were identified through interviews and qualitative content analysis methods. The statistical population in this section included university specialists and experts, managers of knowledge enterprises and competent individuals with executive positions in those companies who have executive experience at decision-making levels. The sample size was obtained by purposive sampling equal to 12 people. Based on the results of the qualitative section, 10 main components and 63 sub-components were recognized to identify real options. After identifying the components, the axial category, including two real options: the abandonment option and expansion option, was identified by experts. These two options were valued for 15 knowledge enterprises by the Black-Scholes model. The results showed that the exercise of real options in knowledge enterprises optimizes the value of the company.

Keywords: Real option, knowledge enterprises, abandonment option
2020 MSC: 91G15, 03B42

*Corresponding author
Email addresses: farahnazjangoo@yahoo.com (Farahnaz Jangoo), seighaly@gmail.com (Mohsen Seighal), hakimehn@yahoo.com (Hakimeh Niki Esfahlan), yb-nahandi@yahoo.com (Younes Badavar Nahandi), salteh2008@gmail.com (Heydar Mohammadzadeh Salteh)

Received: November 2022 *Accepted:* January 2023

1 Introduction

Many researchers have expressed evidence that small and medium-sized knowledge-based enterprises established by entrepreneurs lead to job creation and high wealth. They have stated that knowledge enterprises are a vital resource for creating new jobs. It has been mentioned elsewhere that small technology companies play a vital role in the development of countries, but they face problems due to lack of finance, and this problem is one of the biggest barriers facing entrepreneurs. Financing the technological ideas of entrepreneurs is one of the most important challenges for supporting entrepreneurs, the main problem of venture capitalists is the inability to accurately value their technology, and therefore valuation of technology is one of the most important requirements of commercialization. In most cases, it is one of the main factors disrupting the technology commercialization process and it is considered as the most important discussion between entrepreneurs and investors. At the beginning of the participation, the investors desire to undervalue the entrepreneur's technology and, as a result, receive a greater share of ownership due to their investment fund. On the other hand, the entrepreneurs, due to their engagement in the idea as well as their misunderstanding of the market desire to over-valuate technology to get a higher share of ownership. Therefore, both entrepreneurs and investors pay special attention to valuation because it provides a standard for determining the amount of shares and return on investment. All indicate the importance of the valuation of technology in the field of financing through venture capital.

The conventional financial assessments that are currently used are based on creating a fixed image of the expectations of future events, although these methods can be utilized with reasonable tolerance and approximation as long as the future events do not differ much from the expectations. However, the problem arises when the activity environment has high uncertainty and therefore has a lot of complexity, so in these conditions, a new approach is needed based on which the mentioned problems can be overcome. The results of studies show that the projects that are evaluated by the conventional discounted cash flows (DCF) methods are not reliable because DCF methods don't consider flexibility due to the changes in investment decision-making. This leads to a lower valuation than the reality of investment [23]. Due to the importance of valuation for investors and knowledge enterprises, a method is necessary for these companies to grasp the complexity and flexibility of companies. It can be provided by the real option method. The real option method consists of valuing the flexibility of the project and adding it to the classical net present value. Using this method, better results can be achieved [11]. Therefore, the present study has been done to identify components of the real option to choose in knowledge enterprises.

2 Theoretical framework and literature review of the research

Today, the vital importance and role of innovation in economic growth and prosperity, as well as the retention and survival of organizations in comparison with competitors, is obvious to anyone. Several definitions have been provided for innovation [5]. Innovation is the process of implementing a creative idea and turning it into a product, service or useful method, and the innovative performance of organizations depends on the management of this process. In today's turbulent and complex environment, organizations need to change and improve their products, services, methods and work processes through innovation to grow and survive. Such actions will lead to the innovative performance of organizations, especially knowledge enterprises. Knowledge enterprises, such as software companies, can play an irreplaceable role with creative actions and innovative performance through knowledge creation, dissemination and exploitation as one of the basic elements of a society's economic movement from agent-based economics to knowledge-based economics. One of the most important issues with which the managers of different companies, especially companies with competitors, are faced is the valuation of projects and their success and profitability compared to these competitors. The valuation of (innovative) projects and the degree of success or failure of an organization compared to similar or competing organizations has always been of special importance and necessity for company managers and researchers in the fields of organizational sciences. When the real option is used in the project with capital budgeting, a method and model are required to evaluate it. Discounted cash flows (DCF) or net present value (NPV) predicts the future cash flows of the plan. The main problem with the discounted cash flow method is to ignore flexibility [16].

With the increase of the liberalization and connectedness of the international financial markets, the risks that economic agents face have increased and changed rapidly. The pricing of financial derivatives and, hence, options to manage and survive in these increasingly volatile markets has gained importance and resulted in fast developments in both the literature and practice [18]. Over the past few decades, researchers have been very interested in modeling financial market problems and extracting the prices of various financial derivatives. This development occurred when Black and Scholes and Merton's papers were published in [6, 24]. These papers had a great impact on the financial markets and attracted much scientific interest and set the key principles of option pricing [19]. The Black and Scholes

model became a cornerstone of the option pricing literature since it is widely accepted and used in the financial market [18].

Various researchers have used the Black-Scholes model for real options in financial markets. Some of these researches include the studies of Cox et al. [9], Rendleman and Bartter [30], Rubinstein [31], Boyle [7], Hull and White [17], Scott [32], Naik [26], Amin and Ng [2], Duan [12] and Scott [21]. Researchers such as Macbeth and Merville [22], Dumas et al. [13] and Poon [28] introduced the assumption of instability of underlying assets in the Black-Scholes model and modified this model.

Kobari [20] used the Black-Scholes pricing model to evaluate the effects of environmental policies on industrial greenhouse gas emissions. Szolgayova [34] investigated the technical cost of carbon conservation using real options. Zhang et al. [39], applied the revised Black–Scholes model to consider the effect of volatility and technological development on the value of corporate emissions rights. Zhang et al. [40], used the Black–Scholes model to assess the value of emission rights and compared it with the results of the income method to promote trading in China's emission rights market. Picozzi and West [27] proposed the real option equation as a fractional Langevin equation to observe memory effects in financial time series. Also, due to the complexity of the financial system, investors do not make their decision immediately after receiving financial information, but they wait until the information reaches its threshold. This behaviour can lead to characteristics such as "long memory" [38]. In addition, Andersen and Bollerslev [3] and Müller et al. [25] showed that there is dependence on financial high-frequency data.

In research entitled "Practical finite difference method for solving the multi-dimensional Black-Scholes model in the fractal market", Wang et al. [37] employed a practical finite difference method to research the multi-dimensional fractional Balck-Scholes model. The results showed that if the effect of the Hurst exponent is not considered in optional risk hedging, the result will deviate greatly from the actual result. In their research, entitled "Soliton theory and modulation instability analysis: The Ivancevic option pricing model in the economy", Chen et al. [8] studied real option price wave functions and also the instability analysis of fluctuations has been observed in detail. In addition, the strain conditions for valid solutions under the family conditions have also been reported. Based on the results, two-dimensional, three-dimensional and counter-plots have been simulated by choosing the suitable values of the parameters involved. Finally, the top and low points of pricing in the mentioned intervals have been presented via contour simulations. In a study titled "Option pricing with neural networks vs. Black-Scholes under different volatility forecasting approaches", İltüzer [18] showed that for call options, the neural network is better than Black-Scholes during tranquil times, while Black-Scholes outperforms the neural network during turbulent periods. Regarding put options, the Black-Scholes model is the best model during tranquil periods whereas the neural network is the best model during turbulent periods.

In his research entitled "Valuation of IT Investments Using Real Options Theory", Ullrich [36] investigated the assumptions for the application of valuation models of information technology projects in studied papers. These assumptions included: 1. Existence of a complete market; 2. The certain project costs; 3. The certain duration of the option; and 4. The certain cash outflows. Initially, in this research, information technology projects are divided into three categories, including stochastic information technology projects with public use; Customized information technology projects for special applications; and information technology projects with new technology. The necessary assumptions for the use of the two Black-Scholes models and the binomial tree for the valuation of information technology projects have been stated, and the degree of importance of these assumptions for the use of these models for each category of projects has been determined through reviewing the literature. In the next step, the papers examining each of the assumptions of the mentioned models have been reviewed. Finally, changes in the assumptions have been made according to the nature of the projects.

Abdul Rahimian et al. [1] have conducted research entitled "Option Contracts in Islamic Jurisprudence Perspective". One of the initiatives of experts in financial affairs is to use derivative financial instruments, which play a key role in the growth and fulfilment of financial markets. The main goal of inventing these tools is to deal with risk, which evolves and becomes more diverse over time. One of the most important of these instruments is the option contract, which is more flexible compared to other derivative instruments, and as a result, it is better to cover the risks caused by price fluctuations. However, since the option contract is one of the new emerging contracts, a group of jurists and Juris consulting, especially alam alfighg (Sunni jurists) have considered these contracts to have many deficiencies and have doubted their authenticity in various aspects. Also, the existence of two defects in the same future contracts led to the creation of the right of option. First, in identical future contracts, the price is constant in the contract and avoids the risk of price changes, while both parties cannot benefit from price changes in the market. The second defect is the impossibility of using it to manage contingent and possible debts. In jurisprudential discussion, the right to option cannot be considered similar to a contract or insurance or earnest sale but it can be corrected canonically. In this paper, the theory of Sunni and Shia scholars has been mentioned along with required reasonable explanations.

The review of the literature of research shows that no research has investigated the factors affecting the real options to choose in knowledge enterprises so far. It indicates the innovation of the present research.

3 Research methodology

Today, with the rapid development of science, we see significant progress in all branches of science [4, 14, 29]. The current study is exploratory research in terms of its purpose, while it is mixed (qualitative and quantitative) research. In the qualitative section, collecting qualitative data is done through interviewing with experts. There is an interview strategy for interviews. In the interview strategy, it is better to talk about the steps and issues related to the topic, not about the research variables. When mixed research is done, the interviewer should have full knowledge of the theories of the subject. After conducting the interviews, quantitative models should be extracted. It should be noted that the models are not supposed to be asked by the interviewees or experts. Instead, the questions are about the topic and the model, and the researcher only collects the opinions. In the interviews, the models are not explained to the experts and their opinions are important for research purposes. The topic of the interview is semi-structured and the questions are general. During the interview, the researcher checks the correctness of his/her understanding of the interviewees' statements by asking guiding questions. In the process of sampling among participants, the researcher analyzes the data to complete the incomplete items by receiving new information from the new participant. After conducting a series of interviews, the main and secondary components in the previous interviews are repeated and the researcher can no longer find a new component. At this time, the researcher reaches theoretical saturation. The duration of the interview with each expert was between 30 and 60 minutes. In some interviews, it is possible for the interviewee to say something wrong and deviate from the interview path, but it is the responsibility of the researcher to return the interview path to topics that can later become codes. It should be noted that at the beginning there was no code according to which the interview would be conducted. Interviews are done and codes are extracted based on those interviews.

This section has been done through qualitative content analysis using MAXQDA software. The statistical population of this part included university specialists and experts and managers of knowledge enterprises. In this study, the purposive sampling method was used to select experts and the selection of experts continued until theoretical saturation was reached. Accordingly, 12 individuals were selected as a statistical sample.

In the quantitative section, the statistical population was selected among 6,700 knowledge enterprises that have been registered on the Iranian vice Presidency of Science and Technology website (https://en.isti.ir) and traded on the Tehran Stock Exchange and their financial reports are published on the Codal website (https://www.codal.ir). Finally, 15 knowledge enterprises were selected as the statistical sample during 2019. After collecting the data, the valuation of the real option was done by the Black-Scholes model.

One of the popular models in the option pricing is the Black-Scholes model, because this method is widely used in valuation of financial options and it is easy to use.

The Black–Scholes formula is as follows:

$$C = N(d1)S_0 - N(d2)X\exp(-rT) \tag{3.1}$$

$$D_1 = \left[\ln\frac{S_0}{X} + \left(r + 0.5\sigma^2\right)\right]/\sigma\sqrt{T} \tag{3.2}$$

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

where c equals the value of the call option, S_0 equals the present value of the underlying asset, X equals the investment cost with the negotiated price, r is the risk-free interest rate, T is the maturity date, σ is the annual standard deviation of the future cash flow of the underlying asset, and $N(d1)$ and $N(d2)$ are the standard normal distribution values of $d1$ and $d2$ (that are available as a function in Microsoft Excel).

Black and Scholes claimed that instantaneous price changes follow a geometric Brownian motion (GBM) as follows:

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

Let's u and σ are the mean and standard deviation of the annual return on asset S, respectively, then:

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

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

or

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

The function $\phi(a, b)$ represents the normal distribution with mean and standard deviation equals to a and b, respectively.

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

where Z is a standard normal variable with a mean of zero and a standard deviation of a unit. Another basic assumption of the Black and Scholes model is the indifference of investors towards risk. Therefore, all investors have a risk-free interest rate expectation (r) from investing in the underlying asset. Therefore:

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

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

For a call option at maturity, two situations can be imagined, if the market price is lower than the negotiated price, the value of the option is zero and it is not exercised. If the market price is higher than the negotiated price, the option is exercised, and the cash inflow S and 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 as follows:

$$C_0^1 = \begin{cases} -K, & \geq K \\ 0, & < K \end{cases} \quad \text{Resultant cash outflow after exercise} \tag{3.12}$$

$$C_0^2 = \begin{cases} S, & S \geq K \\ 0, & S < K \end{cases} \quad \text{Resultant cash inflow after exercise} \tag{3.13}$$

If the variable d_2 is shown as Eq. (3.14) as follows:

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

The option is exercised if $S \geq K$ and this is equivalent to $Z \geq -d_2$. Therefore, the probability of exercise of the option is equal to the area under the curve of the normal distribution function from $-\infty$ to d_2 is:

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

and its present value is equal to Eq. (3.16).

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

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

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

and m and s^2 are the mean and variance of the distribution, respectively, then:

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

where in the above model,

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

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

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

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

As mentioned:

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

So the following equation holds:

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

By substituting Eq. (3.24) into Eq. (3.18), the expected value of cash inflow after exercise is obtained as follows:

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

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

and its present value is equal to:

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

by summation of Eq. (3.16) and Eq. (3.25), the value of a call option is equal to:

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

3.1 Process of research implementation

In general, the steps of conducting research based on the grounded theory are as follows [33] (See Fig. 1.).

1. Reviewing theoretical literature on the subject
2. Codifying research questions
3. Collecting data along with analysis until reaching the saturation stage
4. Coding data in three open, axial and selective stages (finding concepts in the data)
   (a) Open coding: First, appropriate codes are assigned to different parts of the data and these boundaries are classified into categories.
   (b) Axial coding: after open coding, the researcher thinks about the different dimensions of these categories and finds the connection between each one.
   (c) Selective coding: In this coding, the categories are refined. After these three coding processes, a theoretical framework is appeared.
5. Memo writing
6. Writing and theoretical categorization

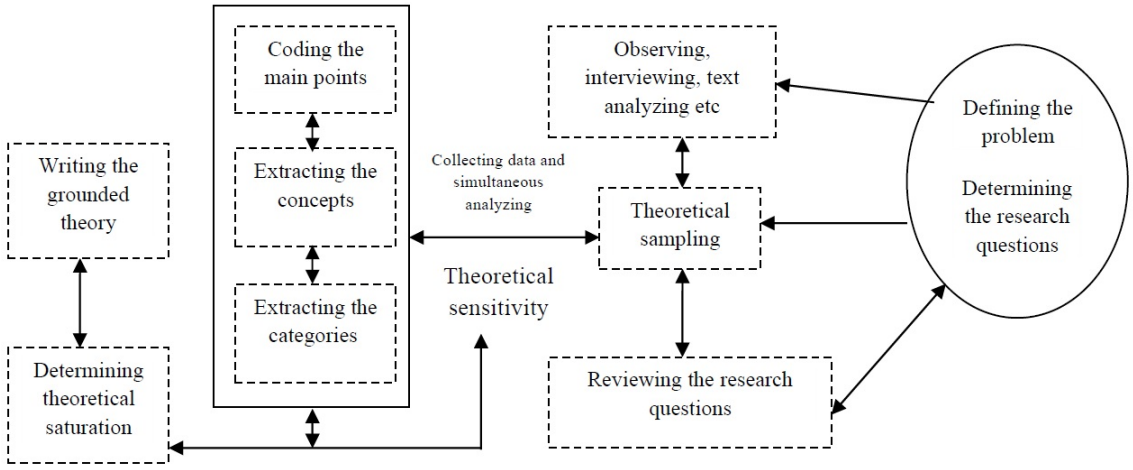

Figure 1: Stages of implementing grounded theory [15]

3.2 Statistical society

Initially, 12 individuals participated in the interview (3 women and 9 men); all of them were over 34 years old and had more than 5 years of work experience. Also, four people had a master's degree and 8 people had a Ph.D. degree.

In the grounded theory, interviews with experts are continued until the researcher reaches theoretical saturation. In order to avoid neglecting all aspects, the researcher should not conduct all the interviews at once and then start coding; rather, this process should be done gradually. In other words, at the end of each interview, all open, axial, and selective coding stages are done, and before starting the next interview, the researcher rethinks on the type of questions [33]. Another way to achieve theoretical saturation is to diversity to the people who are interviewed because it is very likely that people who have been in the same field working together or in the same place for a long time speak in the same language and make the researcher feel a false sense of theoretical saturation (repetition of concepts and categories or relationships). Diversity of interviewees in terms of age, gender, marital status, employment, which are common variables of quantitative research, is another method that leads to getting different points of view in the interviews and gives a diverse range of concepts and categories for the researcher.

4 Research findings

Data conceptualization is the first step in the analysis. For this purpose, the data obtained through interviews was recorded in audio form and after implementation in the text environment and transferring into MAXQDA software V. 12 (special software for qualitative data), it was carefully studied. During the study, similar data having the same meaning was coded under common codes and corresponding concepts were assigned to them. Next, to create the categories, each of the concepts was compared with each other in terms of similarity and semantic proximity to determine their similarities and differences. In this research, 140 open codes were marked. Axial coding is the second analysis stage in the qualitative methods. The purpose of this stage is to identify the relationship between the categories produced in the open coding stage [10]. When identifying connections in the network, it is necessary to check how these categories are related to each other. Finally, 10 main components and 63 sub-components were identified for the selection of real options in knowledge enterprises. The main components include:

1. Optimizing the goal
2. Risk management
3. Intrinsic value
4. Rate of return on investment
5. Optimizing the results
6. Effective factors in real option
7. Macroeconomic policies of government
8. Components of real option
9. Increasing the value of the company
10. Increase in stock price

Next, in order to create categories, each of the concepts was compared with each other to determine their similarities and differences. After choosing the axial category, the data was selectively coded in such a way that the axial category directs the coding and there is no longer concern about concepts that have little importance compared to the axial variable and its subcategories. In other words, the scope of the research is limited to the level of one of several main social processes or conditions that existed in the data. The appearance of the axial variable in the study also acts as a guide for further collecting and analyzing the following data. That is, the axial category directs the theoretical sampling. In this research, the axial category is to choose the real option to maximize the value of the knowledge enterprise. According to the opinion of the experts and the extracted components, two real options were selected as follows:

1. Abandonment options
2. Expansion options

Based on the results collected from the information, and according to examining and analyzing the data with the model proposed in the grounded theory, at the end of the selective coding stage, a conceptual model was created to identify the components of the real option to choose in knowledge enterprises were formed as follows shown in Fig. 2.

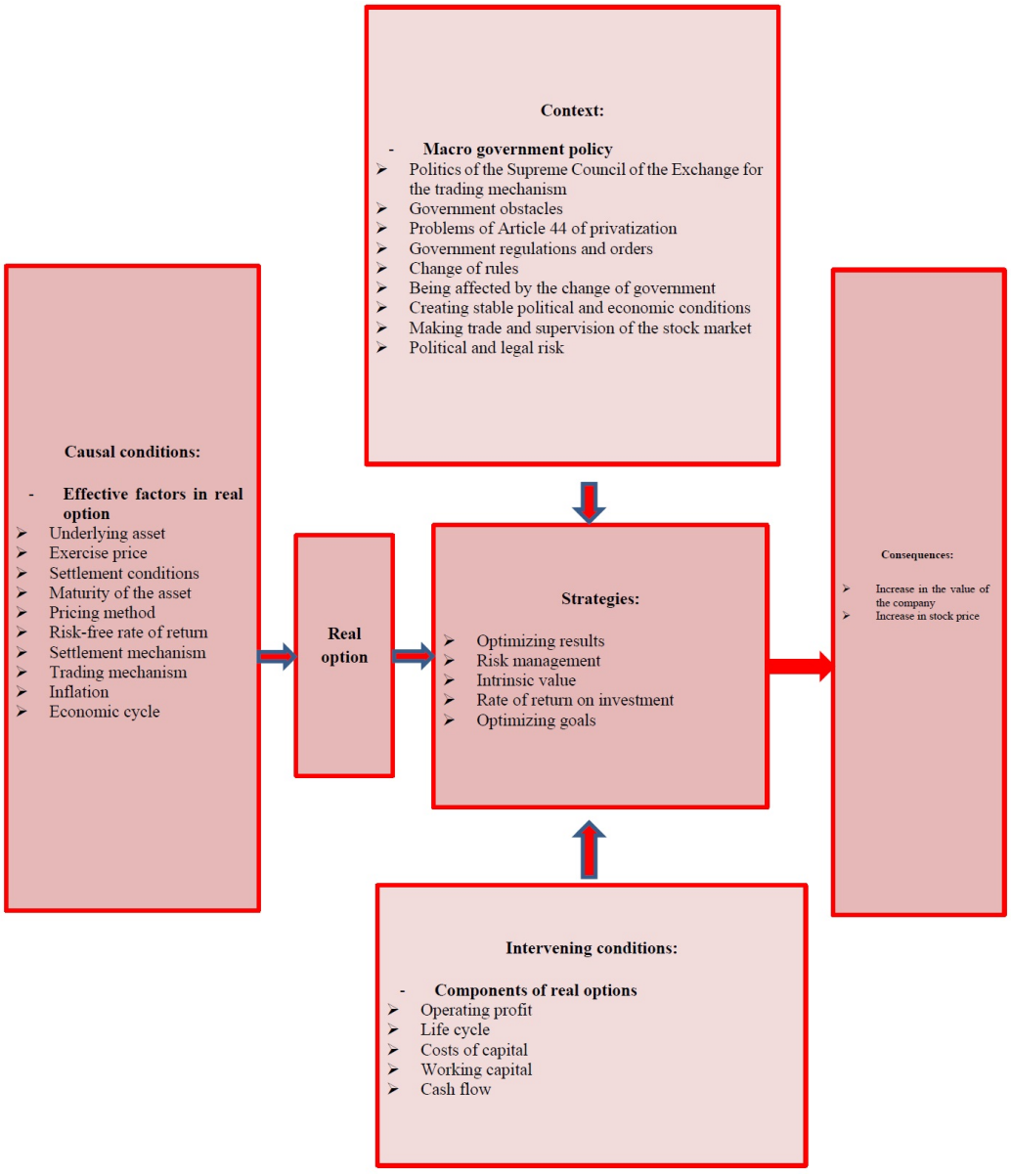

Figure 2: Conceptual model of the research

4.1 Validation of qualitative data

In order to validate the results of the research, the validity and reliability of the findings have been evaluated. In the present study, sources such as interviews with professors, Ph.D. students, and experts have been used. The research has been studied and revised by 2 professors, and required corrections were done to modify or change the theory. The reliability of the data and the correctness of all research steps were confirmed by the experts' careful evaluation of all raw and analyzed data, codes, categories, study process, primary objectives and questions. In addition, in the current research, the intra-subject agreement method was used to calculate the reliability of the conducted interviews. In order to calculate the reliability of the interview using the intra-subject agreement of two coders (raters), three experts were asked to participate in the research as a research rater (coder). Through an amount of agreement and disagreement in the coding within a short and specific time interval, the stability index is calculated for the research. The percentage of intra-subject agreement as an indicator of the reliability of the analysis was calculated using the following formula and the results have been presented in Table. 1.

$$\text{The percentage of intra} - \text{subject agreement} = \frac{(\text{the number of agreements} \times 2)}{\text{total number of codes} \times 100}.$$

Table 1: The results of inter-coder reliability

Number	The title of the interview	Total number of data	Number of agreements	Number of disagreements	Retest reliability (percentage)
1	First	43	18	7	83%
2	Second	51	19	5	74%
3	Third	46	16	6	69%
	Total	140	53	18	75%

As shown in the Table. 1, total number of codes registered by both rater (researcher and cooperator) is equal to 140, the total number of agreements between these codes is 53, and the total number of disagreements between these codes is 18. Using the mentioned formula, inter-coder reliability is 75%, which is higher than 60%. Therefore, the reliability of coding is confirmed.

4.2 Findings of the quantitative section

The input variables of the Black and Scholes model for real option in knowledge enterprises are as follows:

4.2.1 Present value of cash inflows

Cash flow-based models are the most important approach to valuing companies. In these methods, the future ability of the company to generate cash flow is evaluated and there is a look at the future of the company. Therefore, it requires forecasting macroeconomic variables, industry and company in order to estimate the cash flows of the company. Finally, the cash flows are discounted to reach the present value of the stock or company. The company's free cash flow is the money that it has left over in the company after paying all operating expenses and providing the necessary operating expenditures such as working capital and fixed assets and can be paid to capital providers (shareholders and lenders). The way of calculating the company's free cash flow is written in Table 2. The present value of free cash flow of knowledge companies has been presented in Table 3.

Table 2: How to get the company's free cash flow

Operating Profit	
Depreciation	+
Capital costs	−
Investment in working capital	−
Free cash flow of knowledge enterprises	=

4.2.2 Variability of the underlying asset

Modeling price fluctuations is applying econometric time series tools for modeling the conditional mean of random variables, while most economic theories are designed to work with conditional variance or fluctuations in a process. The fluctuations of the financial markets have directed researchers to create practical models for measuring and predicting the fluctuations of stock returns and stock market indices.

Table 3: Calculation of the present value of free cash flow of knowledge companies

Company Name	Operating Profit	Depreciation	Capital costs	Working capital	Free cash flow	Present value of free cash flow
Company 1	11596804	57930	24213.954	22539762	−10909242	−9245120
Company 2	765717	35032	682.876	1984217	−1214150	−1028941
Company 3	261966	22600	2136.258	−224104	506534	429266
Company 4	811250	202190	404.124	172114	840922	712646
Company 5	7356	32425	212955972	30232	−212946423	−180463070
Company 6	11215491	160218	9747.260	3368619	7997343	6777409
Company 7	6975010	214397	6137697	7927585	−6875875	−5827013
Company 8	3526755	56778	3228.260	3895564	−315259	−267169
Company 9	2702813	89250	6259.260	4422038	−1636234	−1386639
Company 10	475463	14266	1288.343	1027741	−539300	−457034
Company 11	3853560	61344	4661.118	4594565	−684322	−579934
Company 12	200519	7311	36369	194641	−23180	−19644
Company 13	1280837	235616	1944.730	2615376	−1100868	−932939
Company 14	1770472	56630	1073.164	987852	838177	710319
Company 15	4367777	59779	7856.564	4664026	−244327	−207056

Table 4: Calculation of annual fluctuations of companies.

Company Name	Daily fluctuations	Annual fluctuations
Company 1	0.033366	0.63745
Company 2	0.02938	0.56134
Company 3	0.03109	0.59395
Company 4	0.02864	0.5471
Company 5	0.035319	0.6747779
Company 6	0.03015	0.57597
Company 7	0.034	0.64955
Company 8	0.0352	0.67244
Company 9	0.03128	0.59755
Company 10	0.03821	0.72999
Company 11		0.5571
Company 12		0.59395
Company 13		0.59500

4.2.3 Maturity date of option

For financial options, the maturity date is quite clear (it is mentioned in the contract), but in many cases it is not true for a real option. Often it is not clear how much time is needed to exercise an option, so, one year is considered for this purpose. Therefore, in this study, for more accurate evaluation, the data from 2019 was used.

4.2.4 Risk- free interest rate

The risk-free interest rate used in real option models is usually based on the rate of return of a US Treasury bond, which is equivalent to a corporate bond in Iran. However, according to the opinion of experts and the fact that only 5% of corporate bonds are used in Iran, the conventional interbank rate, which is 18%, is considered as a risk-free interest rate.

4.2.5 Calculation of abandonment and expansion options

According to the information obtained from the financial statements and their analysis, the pricing for the abandonment and expansion options is calculated by Python software as follows:

The distribution function is normal.

$$
\begin{aligned}
ROV &= S \times e^{(-dt)} \times N(d1) - K \times N(d2) \times e^{(-rt)} \\
d1 &= (\ln(S \times e^{(-dt)}/X) + (r + (\sigma^2/2))T)/(\sigma\sqrt{T}) \\
d2 &= (\ln(S \times e^{(-dt)}/X) + (r - (\sigma^2/2))T)/(\sigma\sqrt{T}) \\
N(-d1) &= 1 - N(d1) \\
N(-d2) &= 1 - N(d2)
\end{aligned}
$$

The results of calculating the value of abandonment and expansion options have been presented in Tables 5 and 6, respectively.

Table 5: Calculation of the value of the abandonment option

Company Name	S	σ	R	K	t	Abandonment option
Company 1	−9245120	0.63	0.18	24213.954	1	0
Company 2	−1028941	0.59	0.18	682.876	1	0
Company 3	429266	0.59	0.18	2136.258	1	427481.863
Company 4	712646	0.54	0.18	404.124	1	712308.447
Company 5	6777409	0.67	0.18	9747.260	1	6769267.4
Company 6	−267169	0.57	0.18	3228.260	1	0
Company 7	−1386639	0.64	0.18	6259.260	1	0
Company 8	−457034	0.67	0.18	1288.343	1	0
Company 9	−579934	0.59	0.18	4661.118	1	0
Company 10	11146	0.72	0.18	36.369	1	11115.6221
Company 11	−932939	0.55	0.18	1944.730	1	0
Company 12	710319	0.59	0.18	1073.164	1	709422.68
Company 13	−207056	0.59	0.18	7856.564	1	0

As can be seen in the above table, companies whose free cash flows are negative, their abandonment option becomes zero and they cannot use the abandonment option. Even when their time efficiency increases, their option is still zero and they cannot finance this way to implement their projects.

Table 6: Calculation of the value of the expansion option

Company Name	S	σ	r	K	t	Expansion option
Company 1	562159	0.63	0.18	48428	1	521708.826
Company 2	33817	0.59	0.18	1775	1	32334.3954
Company 3	539363	0.59	0.18	3204	1	536686.794
Company 4	1124940	0.54	0.18	647	1	1124399.58
Company 5	14374524	0.67	0.18	17545	1	14359869.2
Company 6	2121663	0.57	0.18	5811	1	2116809.24
Company 7	441533	0.64	0.18	11267	1	432122.011
Company 8	65362	0.67	0.18	2963	1	62887.0952
Company 9	1050955	0.59	0.18	6992	1	1045114.79
Company 10	113087	0.72	0.18	58	1	113038.554
Company 11	42488	0.55	0.18	3695	1	39401.6777
Company 12	1310116	0.59	0.18	1502	1	1308861.42
Company 13	2748822	0.59	0.18	14142	1	2737009.61

Most portions of knowledge enterprises' income and profits are the result of their expansion projects. By examining the report provided by the board of directors of each company, the exploitation of the expansion plans of knowledge enterprises in the future years was calculated. For this reason, the present value of their cash flows is positive. Consequently, the results obtained from the above table show that those companies can use expansion options to finance their projects.

5 Conclusions and suggestions

5.1 Conclusion

The real option is a systematic approach in which economic modeling can be done using financial theory, economic analysis, operations research, decision theory, and statistical science. Real option theory in a dynamic decision-making environment and uncertain business environments is an attitude that is used to evaluate investments, valuations and expenses of economic plans and projects through strategic decision-making. One of the basic assumptions of the real options theory is that the manager of the company is a rational individual with sufficient competence in the field of related decisions, and in this regard, he considers the benefit of the shareholders and does his best to maximize their wealth.

In this paper, in the qualitative section, open, axial and selective coding was done based on the qualitative content analysis of the interviews to implement the selection of effective components in the real options to choose in knowledge enterprises. Based on the results, 10 main components and 63 sub-components were identified as the real options to choose from in knowledge enterprises. The results obtained in this research are consistent with those of Wang et al. [37], Chen et al. [8] and Tehrani and Soroush [35] studies.

After identifying the effective components in the real options to choose in knowledge enterprises, the options obtained from the qualitative section were valued by the Black-Scholes method. For the Black-Scholes model, the variables of the qualitative part were converted into a computable form for knowledge enterprises, and then the relevant statistical data was collected for 15 knowledge enterprises. Quantitative variables include operating profit, depreciation, capital costs, working capital and free cash flow of knowledge enterprises.

The result obtained after examination of the main and sub-components of the research led to two real options to be chosen, called abandonment and expansion options. In the quantitative part of this paper, these options are valued using the Black-Scholes model method. Finally, the value of the cash flows of knowledge companies was calculated and compared both before and after the exercise of the options.

The axial category in the first part of the present research is to find the optimal real option to increase the value of knowledge enterprises. Therefore, to choose the real option in knowledge enterprises two real options, i.e. abandonment and expansion options were identified according to the components obtained in the conceptual model of the research (optimizing the goal, risk management, intrinsic value, rate of return on investment, optimizing the results, effective factors in real option, macroeconomic policies of the government, components of real option, increasing the value of the company, increase in stock price). According to the conceptual model, the use of these two options increases the value of knowledge enterprises. To verify this result, the real data of knowledge enterprises registered on the Iranian Vice Presidency of Science and Technology website was used. When the present value of the cash flows of the companies was calculated, the calculations showed that the cash flows of these companies were negative. Then, using the Black-Scholes model, valuation of these two real options was done and it was observed that when knowledge enterprises use these two options to finance their expansion projects, the cash flow of these companies is not only positive but also shows good value.

5.2 Suggestions

- Investors always try to evaluate and select suitable projects to allocate their limited resources to these projects optimally. Doing a field study to investigate the level of investors' attention to the real options as one of the components that determine the value of the company can be one of the interesting topics for future research.
- The role of the companies' real options in determining the expected rate of return of the companies' stock should be investigated.
- The risk premium of companies' real options should be investigated.
- The increasing amount of research in the field of applying the real options theory in investments to examine the role of real options in the reaction of investors in the capital market.
- Combining real options theory with the game theory based on the competitive environment in different products and services of the country and studying organizational, environmental and operational challenges to institutionalize the application of real options theory in the analysis of investment scenarios in different fields.

References

[1] M.H. Abdul Rahimian, A. Haghshenas, and H. Ramtin, *Option contracts in Islamic jurisprudence perspective*, Islamic Econ. Bank. **7** (2017), no. 23, 31–43.

[2] K.I. Amin and V.K. Ng, *Option valuation with systematic stochastic volatility*, J. Finance **48** (1993), 881–910.

[3] T.G. Andersen and T. Bollerslev, *Heterogeneous information arrivals and return volatility dynamics: Uncovering the long-run in high frequency returns*, J. Finance **52** (1997), 975–1005.

[4] H. Ariakia, M. Ramezani, and A. Rajabzadeh Ghatari, *An agent-based market simulation with social effects*, Transact. Data Anal. Soc. Sci. **3** (2021), no. 1, 23–29.

[5] A. Baregheh, J. Rowley, and S. Sambrook, *Towards a multidisciplinary definition of innovation*, Manag. Decis. **47** (2009), no. 8, 1323–1339.

[6] F. Black and M. Scholes, *The pricing of options and corporate liabilities*, J. Pol. Econ. **81** (1973), 637–654.

[7] P.P. Boyle, *A lattice framework for option pricing with two state variables*, J. Financ. Quant. Anal. **23** (1988), 1–12.

[8] Q. Chen, H.M. Baskonus, W. Gao, and E. Ilhan, *Soliton theory and modulation instability analysis: the Ivancevic option pricing model in economy*, Alexandria Eng. J. **61** (2022), no. 10, 7843–7851.

[9] J.C. Cox, S.A. Ross, and M. Rubinstein, *Option pricing: A simplified approach*, J. Financ. Econ. **7** (1979), 229–263.

[10] J.W. Creswell and C.N. Poth, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*, Sage Publications, 2016.

[11] G. Desaché, *How to value a start-up. The use of options to assess the value of equity in start-ups*, Available in: www.vernimmen.net/ftp/Research_paper_v3.pdf, 2014.

[12] J.C. Duan, *The GARCH option pricing model*, Math. Finance **5** (1995), 13–32.

[13] B. Dumas, J. Fleming, and R.E. Whaley, *Implied volatility functions: empirical tests*, J. Finance **53** (2002), 2059–2106.

[14] J. Haddadnia, O.R. Seryasat, and H. Rabiee, *Thyroid diseases diagnosis using probabilistic neural network and principal component analysis*, J. Basic Appl. Sci. Res. **3** (2013), no. 2, 593–598.

[15] M. Farasatkhah, *Coding Guide for Qualitative Researchers*, Tehran: Agah Publications, 2015.

[16] F. Heibati, N. Gholam-Ali and H. Hassanzadeh, *Application of constraint theory in company evaluation based on real option*, Financ. Eng. Secur. Manag. **1** (2010), no. 1, 1–17.

[17] J. Hull and A. White, *The pricing of options on assets with stochastic volatilities*, J. Finance **42** (1987), 281–300.

[18] Z. İltüzer, *Option pricing with neural networks vs. Black-Scholes under different volatility forecasting approaches for BIST 30 index options*, Borsa Istanbul Rev. **22** (2022), no. 4, 725–742.

[19] G. Karipova and M. Magdziarz, *Pricing of basket options in subdiffusive fractional Black–Scholes model*, Chaos Solitons Fractals **102** (2017), 245–253.

[20] L. Kobari, S. Jaimungal, and Y. Lawryshyn, *A real options model to evaluate the effect of environmental policies on the oil sands rate of expansion*, Energy Econ. **45** (2014), 155–165.

[21] L.O. Macbeth, *Pricing stock options in a jump-diffusion model with stochastic volatility and interest rates: applications of Fourier inversion methods*, Math. Finance **7** (2002), 413–426.

[22] J.D. Macbeth and L.J. Merville, *An empirical examination of the Black-Scholes call option pricing model*, J. Finance **34** (1979), 1173–1186.

[23] E.A. Martínez-Ceseña and J. Mutale, *Application of an advanced real options approach for renewable energy generation projects planning*, Renew. Sustain. Energy Rev. **15** (2011), no. 4, 2087–2094.

[24] R.C. Merton, *Theory of rational option pricing*, Bell. J. Econ. Manag. Sci. **4** (1973), 141–183.

[25] U.A. Müller, M.M. Dacorogna, and O.V. Pictet, *Heavy tails in high-frequency financial data*, A Practical Guide to Heavy Tails: Statist. Tech. Appl. **4** (1998), 55–78.

[26] V. Naik, *Option valuation and hedging strategies with jumps in the volatility of asset returns*, J. Finance **48** (1993), 1969–1984.

[27] S. Picozzi and B.J. West, *Fractional Langevin model of memory in financial time series*, Phys. Rev. E **65** (2002), no. 3, 037106.

[28] S.H. Poon, *A Practical Guide to Forecasting Financial Market Volatility*, England, Wiley Finance, 2005.

[29] O. Rahmani-Seryasat, J. Haddadnia, and H. Ghayoumi-Zadeh, *A new method to classify breast cancer tumors and their fractionation*, Ciência Natura **37** (2015), no. 4, 51–57.

[30] R.J. Rendleman and B.J. Bartter, *Two-state option pricing*, J. Finance **34** (1979), 1093–1110.

[31] M. Rubinstein, *Displaced diffusion option pricing*, J. Finance **38** (1983), 213–217.

[32] L.O. Scott, *Option pricing when the variance changes randomly: Theory, estimation, and an application*, J. Financ. Quant. Anal. **22** (1987), 419–438.

[33] A. Strauss and J. Corbin, *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, Thousand Oaks, CA: Sage, 1998.

[34] J. Szolgayova, A. Golub and S. Fuss, *Innovation and risk-averse firms: options on carbon allowances as a hedging tool*, Energy Pol. **70** (2014), 227–235.

[35] R. Tehrani, S.M. Mirlouhi and M.R. Golkani, *Calculating the value of real options with different approaches in the Tehran stock exchange*, Asset Manag. Financ. **8** (2020), no. 2, 1–12.

[36] C. Ullrich, *Valuation of IT investments using real options theory*, Bus. Info. Syst. Eng. **5** (2013), 331–341.

[37] J. Wang, S. Wen, M. Yang, and W. Shao, *Practical finite difference method for solving multi-dimensional Black-Scholes model in fractal market*, Chaos Solitons Fractals **157** (2022), 111895.

[38] W.L. Xiao, W.G. Zhang, X. Zhang, and X. Zhang, *Pricing model for equity warrants in a mixed fractional Brownian environment and its algorithm*, Phys. A: Statist. Mech. Appl. **391** (2012), no. 24, 6418–6431.

[39] H.J. Zhang, M.S. Duan, and Z. Deng, *Have China's pilot emissions trading schemes promoted carbon emission reductions? The evidence from industrial subsectors at the provincial level*, J. Clean. Prod. **234** (2019), 912–924.

[40] Z.Y. Zhang, Y. Hao, and Z.N. Lu, *Does environmental pollution affect labor supply? An empirical analysis based on 112 cities in China*, J. Clean. Prod. **190** (2018), 378–387.