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Intellectual property valuation: developing a model for patent valuation

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Abstract

With the growing knowledge of economics, the role of intellectual property in the development of international businesses and the boom of the national economy has become increasingly pronounced. There are many items on the intellectual property list, but the patent may be the most important intellectual property. Patent rights that bring patent owner immunity are very valuable. These licenses have been tradable in certain markets, like many other economic markets, and one of the concerns of technology researchers has always been to calculate the value of patents and to decide whether or not to buy them. The present study has developed a system for patent valuation. In the first step, the decision to invest or not invest in intellectual property (policy making) is examined using Ohlsen's model. In the second step, the patent valuation is done by using the real option valuation methods. Implementation of Ohlsen's model in companies listed on the Tehran Stock Exchange has highlighted the importance of advertising as one of the customer-centric intellectual property of the share price. in second step, a patent is valued in terms of the option to assign and simulate future patent cash flows using the average return process.

Keywords: patent, data mining, real possession, valuation

1. Introduction

Decision-making is always one of the challenges for corporate executives. One of the most important issues is determining management's policy towards investing in intellectual property. The manager of a company must first decide whether or not to invest in intellectual property depending on the particular industry in which the company operates. In the next step, the manager should identify a list of patent rights that will most likely create value for the company in the future. This is possible with the help of patent databases and prioritization techniques based on the company's strengths and weaknesses. In the final step, the manager must determine the amount of the patent

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payout and this requires a valuation technique that is easy to use despite high accuracy. Valuation methods are categorized into traditional valuation and option valuation methods [15]. The real Option valuation method is a newer method than traditional methods. This method often uses the Black-Scholes formula. However, many valuation adjustments have been made, such as adding cash dividends to the method. According to the World Bank, in 2015, Iran is the second largest economy in the Middle East and North Africa after Saudi Arabia and has the third largest population after Pakistan and Egypt in the region. However, the Iranian government's revenues are largely dependent on oil, which accounts for 35% of government funding in 1995. Given the increasing competition at the international level and the technology-rich countries overtaking natural wealth countries, recognizing and evaluating intellectual property as a source of sustainable growth is essential. In view of the foregoing, the recognition, evaluation and valuation of intellectual property is of paramount importance at both national and international levels. The purpose of the present study is to provide a system, which will facilitate the decision-making process of investing in relation to investing in intellectual property.

In this article, two questions need to be answered thoroughly and clearly to explain the position of the research ahead. The two questions are: (1) what is intellectual property? And (2) what does valuation mean?

The purpose of the present study is to provide a patent decision making system related to investment in patent. This system will help to make the management of the company more accurate and faster. What distinguishes this research from previous research is the development of a comprehensive patent valuation system. This research has taken a new approach and a step-by-step approach to solving managerial issues related to investment in patent. At each step, improvements have been made to previous research methods and at some stages a new approach has been employed to obtain more accurate results.

2. Theoretical foundations and research background

2.1. Intellectual property

Intellectual property refers to the fabrication of the human mind, which includes inventions, literary works and works of art. Intellectual property also includes symbols, images and names in the business world. Intellectual assets are divided into the following two categories:

(1) Industrial Property: Includes patents, trademarks, industrial designs and geographical indications.

(2) Copyright: Includes literary works, films, music and architectural designs.

2.2. All kinds of intellectual property

In general, it divided intellectual property into five categories [19].

(1) Patent: A patent is an exclusive right given to the inventor of a product or process that creates a new way of doing something or proposes a new technical way to solve a problem. A patent gives its owner immunity for a limited period, which is usually twenty years.

(2) Trademark: A trademark is a distinctive trademark that identifies a particular product or service produced or furnished by an individual or company. This system helps the customer to develop a product based on unique brand features and quality.

(3) Industrial design: Industrial design refers to the ornamental and aesthetic aspects of the product; the design may include three-dimensional features such as the shape and surface of the product or include two-dimensional features such as lines, colors, patterns and prints.

(4) Geographical indication: Geographical indication is the symbol used on goods that belong to a particular location and have quality and reputation because of their locational origin. Usually, the label includes the location where the product is manufactured.

(5) Copyright: The Copyright Act provides for authors, artists, and other creators. Most of these rights belong to their works [19].

2.3. Classification of intellectual property of the company

The intellectual property of the company has three categories: (1) human assets, (2) structural assets, and (3) customer-centric assets [14].

2.4. Valuation

It means putting value on a business. Valuation can include assets and inventory. The valuation process leads to the estimation of economic value, dollar value and fair market value [17].

2.5. Types of valuation methods

Valuation methods are categorized into traditional valuation and option valuation methods [15]. The real option valuation method is a newer method than traditional methods. This method often uses the Black-Scholes formula. However, many valuation adjustments have been made, such as adding cash dividends to the method.

2.6. Research background

Given the focus of the current research on the topic of valuation, the research is divided into: (1) traditional valuation (revenue-based, cost-based and replacement value) and (2) valuation using real option.

Berzkalne and Zelgalve surveyed 65 ballistics companies to find a link between intellectual property and corporate value. Then, using the Tobin index as a measure of firm intellectual property and correlation analysis, it has been shown the relationship between intellectual property and the value of companies in ballistic countries [2]. In another study, Saad and Zantout pointed to the incline in the returns of large companies that have invested heavily in research and development [16]. Grimpe and Hussinger looked at the effect of patent acquisition on firm value by examining 1428 technology transfers and by means of regression [10]. Fayyaz Ahmad et al, in their research using simultaneous equations, pointed to the rise in the level of income under patent in pharmaceutical companies. However, this study also points to the negative impact of patent enforcement on the growth of developing countries [3]. Ernst et al, examined the effects of managerial dimensions on the value of a firm's intellectual property. In this study, the positive effect of intellectual property information management and intellectual property protection management on firm profitability and patent portfolio value has been shown by linear regression [6].

Yu and Hong in their research demonstrated the higher power of the number of company patents than the costs of investing in research and development to explain share price changes [22]. Wang and Hsieh identified 10 key variables affecting intellectual property. These criteria are then weighted using the hierarchical analysis process, thus introducing three categories of patents and providing a suitable strategy for each [18]. Grimaldi et al, provided effective frameworks for managing patent rights, using well-known indicators such as the number of patient referrals [9]. Motta et al, considered

the humanities metrics along with the patent criteria to be more effective in evaluating investment projects more accurately [5]. Clausen and Hirth presented a new indicator based on their income. Describing a higher percentage of intellectual property value changes has been shown in this study [4]. Ho and Liao illustrate the fuzzy-binomial method presented in their previous research by [12]. Agliardi makes the value of a patent subject to the possibility of applying intellectual property by using fuzzy method and real option [1]. Hoe and Diltz applied real option to valuation in pharmaceutical industry contracts. In this study, the profit-sharing ratio is used to allocate value between the issuer and the licensee [13]. Xiao-yang and Chang-xin real option contracts were used to evaluate intellectual property. This study points to the positive effect of fluctuations on the value of intellectual property [21]. Zee and Spinler enacted a real option contract to evaluate public sector technologies. In this study, upper and lower bounds of option have been used and the two variables of product unit cost and technology demand variables have been taken into account [23]. Wilson proposed a retrospective method for evaluating patent licensing. In this study, the value of payments has been periodically obtained by using indicators affecting the value of patent [20]. Heiden has investigated the standard method of patent valuation in the telecommunications industry [11].

3. Development of proposed models

This section is divided into two parts: (1) policymaking (decision making on investing in intellectual property) and (2) valuation of patents. Progressive research has provided a new and comprehensive model for patent valuation; the steps of this research are as follows:

1. Policy making (decision making on investment in intellectual property): In this step the relationship between company value and investment in patents is examined. This step will help management to decide whether or not to invest in patent rights.

2. Valuation of patents: In this step, patents that are of high value to the company are valued.

3.1. Introduction to Ohlsen Model

Ohlsen's model incorporates the residual income valuation method and the linear information model to provide a new model to explain changes and factors affecting share prices. Relation (1) shows the Ohlsen model:

$$P_t = BV_t + \alpha_1 X_t^a + \alpha_2 v_t \qquad (1)$$

In Ohlsen's model, book value (BV), residual income χ^a, and other information (v) are factors that influence the firm's share price. Ohlsen's model uses accounting information to evaluate a company and considers the book value as the fair price of the company, and also calculates the future dividend of the company using revenue accounting [8].

The financial variables of Ohlsen's model are book value (BV) and residual income χ^a. Ohlsen's model assumes accounting information to be inconsistent. However, on the basis of generally accepted accounting principles of accounting (GAPP), in the real market most of the accounting information is skewed, which is the basis of conservative accounting. The modified Ohlsen model is shown in relation (2).

$$P_t = \alpha_0 + \alpha_1 BV_t + \alpha_2 X_t^a + \alpha_3 v_t \qquad (2)$$

Proportion of Major Customers (PMC), Advertising Expenses Ratio (ADV), Revenue Growth Rate (RG), Years of Corporation Establishment (YCE), R&D Density (RDD), Numbers of Patents (PAT) and Revenues Per Employee (RPE), Software Acquisition Intensity (ISOF), Pension Cost (PENS), Herfindahl-Hirschman Index (HHI), Relative Patent Position (RPE) are studied.

3.1.1. Modeling

As stated in the stepwise regression method, the aim is to obtain the final model of the problem. The initial model of the problem is written according to Ohlsen's model and the indices introduced in relation (3).

$$P_{it} = BV_{it} + \chi^{a}_{it} + PMC_{it} + ADV_{it} + RG_{it} + ISOF_{it} + YCE_{it} + PAT_{it} + RDD_{it} + RPP_{it} + HHI_{it} + RPE_{it} + PENS_{it} \quad (3)$$

3.2. Valuation of patent rights

The final part of this section is about calculating the value of a patent and deciding whether to buy a patent. In the first part of this section, the reason for applying the research valuation method, the real option, is explained. In this study, the developed average return model based on assumptions about cash flows is used to evaluate the patent, these assumptions about future patent rights cash flows are summarized in Table (1).

Table 1: Valuation assumptions

No	Description
Assumptions (1)	Patents are traded in the intellectual property market and this market is efficient.
Assumptions (2)	There is a direct relationship between the market price of a patent and the validity of a patent.
Assumptions (3)	It is not possible to accurately calculate intellectual property cash flows due to the absence of similar assets.
Assumptions (4)	The purchased patent has the ability to be resold in the intellectual property market.

3.2.1. Modeling

Since the defined and executable real options are different depending on the economic project (base asset), it is therefore necessary to first briefly introduce the set of real options and then examine some of the basic features of the underlying asset. After knowing the set of real options and the characteristics of the underlying assets (economic project), it is possible to decide whether or not to evaluate each of them for the economic project. By examining the literature on actual options, four types of options have been identified, which are summarized in Table (2) along with their operational definitions.Since the defined and executable real options are different depending on the economic project (base asset), it is therefore necessary to first briefly introduce the set of real options and then examine some of the basic features of the underlying asset. After knowing the set of real options and the characteristics of the underlying assets (economic project), it is possible to decide whether or not to evaluate each of them for the economic project. By examining the literature on actual options, four types of options have been identified, which are summarized in Table (2) along with their operational definitions. Among the options in Table (2), option to abandon is the only type of real option that can be applied to a patent and the patent buyer can sell the purchased license in the patent market at his own discretion. The details of exercising this option will then be stated.

Although there are various methods such as: Black Scholes method, Monte Carlo simulation method, differential equation methods to calculate the real option value, but often the binomial tree is used to evaluate the real option [7].

Table 2: Definition of types of real option contracts

No	Name	Definition
1	Option to Defer	Option to defer is postpone investment on a specific project.
2	Option to Expand	Option to purchase is greater than the product if satisfied with the product purchased first.
3	Option to Default	Option to default in the commercialization stage is after the unsatisfactory first stage of product commercialization.
4	Option to Abandon	The option to sell the product in the event of dissatisfaction with the performance of the product

4. Research results

4.1. The results of model implementation at the policy level

In this section, first, the descriptive statistics indices of the model are introduced and then the assumptions are tested by entering the order of each of the variables. SPSS software version 22 was used to obtain the results.

4.1.1. Data

To implement the model, out of 343 companies listed on the Iranian Stock Exchange, 106 companies were selected from the pharmaceutical, automotive, basic metals, minerals, petrochemical, food and sugar industries. The data of these companies have been considered for two consecutive years in 2016, with restrictions such as availability of information on final price and profitability. SPSS software version 22 was used to obtain the results.

4.1.2. Examination of financial variables

To test the first assumption, we calculate the share price regression against the book value and the residual income according to (4).

$$P_{it} = \alpha_0 + \alpha_1 BV_{it} + \alpha_2 X^a_{it} + \epsilon_t \qquad (4)$$

For this purpose, the significance of the regression is first examined and the results of the model implementation are presented in Table (3). According to Table (3), the regression model with any

Table 3: Significant investigation of relationship between financial variables and market price

Model (1)	$\mathbf{R^2}$	**F**	**P-Value**
	0.502	51.924	0.000

confidence coefficient is significant. The model coefficients are now analyzed separately, and the results of the model implementation are shown in Table (4).

Table 4: Examine the relationship between market price and financial variables.

Model (1)	**Coefficients**	**P-Value**
Constant	56.918	0.945
χ^a	2.660	0.068
BV	0.271	0.000

Significance of coefficient of variation of book value is accepted with each coefficient and residual income variable of coefficient of significance is 90% and less acceptable for coefficients of confidence. Given the value of 0.502 for R^2 and the significance of the coefficients of the financial variables, it can be stated that the assumption (1) that the effect of the financial variables on the value of the book value is significant cannot be rejected.

4.1.3. Investigating human variables

After examining the financial variables to test the second hypothesis, the significance of human capital variables is entered into the model as shown in (5).

$$P_{it} = \alpha_0 + \alpha_1 BV_{it} + \alpha_2 \chi^a_{it} + \alpha_3 RPE_{it} + \alpha_4 PENS_{it} + \epsilon_t \qquad (5)$$

For this purpose, new variables are introduced into the model whose results are shown in Table (5).

Table 5: Examines the relationship between market price and human variables.

Model (2)	**Coefficient**	**P-Value**
Constant	56.918	0.838
χ^a	2.660	0.078
BV	0.271	0.000
PENS	0.001	0.585
RPE	0.001	0.738

According to the results of Table (5), the regression coefficients of human variables with 90% confidence coefficient are not significant. The value ofR^2 also increased by only 0.02, so it can be said that the second assumption that human variables influence the share price is rejected.

4.1.4. Examination of customer-centric variables

After examining the financial and human variables, they enter into the model to test the third hypothesis of the significance of customer-centric variables as shown in relation (6).

$$P_{it} = \alpha_0 + \alpha_1 BV_{it} + \alpha_2 \chi^a_{it} + \alpha_3 PMC_{it} + \alpha_4 ADV_{it} + \alpha_5 RG_{it} + \epsilon_t \qquad (6)$$

For this purpose, new variables are entered into the model whose results are shown in Table (6).

Table 6: Examine the relationship between market price and customer- centric.

Model (3)	**Coefficient**	**P-Value**
Constant	56.918	0.491
χ^a	2.660	0.1
BV	0.271	0.000
RG	126.967	0.535
ADV	15.441	0.009
PMC	-538.159	0.696

According to the results of Table (6), the regression coefficients of revenue growth and the ratio of major customers to 90% confidence coefficient are meaningless but the variable advertising coefficient is less than 99% for confidence coefficient values. The value of R2 regression also ranged from 0.502 to 0.526. Therefore, the third assumption at the significant level of more than 1% cannot be rejected and the cost of advertising is effective in market share.

4.1.5. Examination of structural variables

After examining the financial, human and customer-centric variables, they enter into the model to test the third hypothesis of the significance of the customer-centric variables as shown in relation (7).

$$P_{it} = \alpha_0 + \alpha_1 BV_{it} + \alpha_2 \chi^a_{it} + \alpha_3 PMC_{it} + \alpha_4 ADV_{it} + \alpha_5 ISOF_{it} + \alpha_6 YCE_{it} + \alpha_7 PAT_{it} + \alpha_8 RDD_{it} + \alpha_9 RPP_{it} + \alpha_{10} HHI_{it} + \epsilon_t \qquad (7)$$

For this purpose, new variables are introduced into the model whose results are shown in Table (7).

Table 7: Examine the relationship between market price and structural variables

Model (4)	**Coefficient**	**P-Value**
Constant	56.918	0.491
χ^a	2.660	0.095
ADV	16.715	0.005
HHI	4954.588	0.739
RPP	1024.977	0.714
RDD	8081.324	0.571
PAT	-10.126	0.831
YCE	-11.247	0.744
ISOF	65359.666	0.511

According to Table (7), no significant structural variance of the model is acceptable at 90% confidence. Therefore, the fourth assumption, which shows the relationship between market price and structural variables, is rejected.

4.1.6. Final model of market price

Table (8) shows the significance of the three coefficients of the final model.

Table 8: The final coefficients of the market price model

Model (5)	**Coefficient**	**P-Value**
Constant	56.918	0.091
χ^a	0.244	0.01
BV	2.229	0.000
ADV	14.813	0.058

According to the results, only three variables: residual income, book value and advertising cost are effective on the market value with 90% confidence level, so the final market price model can be rewritten in the form of a relation (8).

$$P_{it} = 56.918 + 2.229(BV_{it}) + 0.244(\chi^a_{it}) + 14.813(ADV_{it}) + \epsilon \qquad (8)$$

4.2. Results of patent valuation

In the first part of this section, the intellectual property and patent market is introduced, and then we describe how to simulate the future price of a patent. Subsequently, intellectual property valuation was performed with the option of assignment using the binomial tree method.

4.2.1. Intellectual property index and examined patent

The market basket yield and standard deviation of this return are necessary for patent valuation, so it is necessary to select a specific intellectual property market and calculate these values. In the present study, the Ocean Tomo 300 patent index was used to calculate the mean and standard deviation of the market basket. The index, the first intellectual property-based index, represents the value of 300 companies that have the highest intellectual property value to book value ratio. This index is calculated and published by the Nice-Euronext group. Figure (1), which shows the performance of the first 9 years of the index against the 500S & P index, shows a better performance than this common index. This patent index is used in the present research to calculate the market basket efficiency and standard deviation of the patent index as a representative of the market basket of patents.

It also uses the BizQuest system to choose a patent. Founded in 1994, the system aims to provide an environment for business sales and sales. Products on this international site include patents and new technologies that sellers and buyers can purchase from these sellers by visiting this site, if needed. In the present study, the evaluation of a surveillance camera is investigated. The technology of production of this surveillance camera, along with its manufacturing equipment and patent, has been auctioned on the BizQuest Web site. Also, information such as purchase price and expected cash flow in the camera specifications section is provided to buyers, which will be provided in the following sections while evaluating the details of this information.

Figure 1: Comparison of patent index with 500 S&P

4.2.2. Simulation of patent cash flow

This section simulates patent cash flows using the extended average return process and the use of the second version of the 2017 Matlab program. Patent information is first required to be written; the information required for patent valuation is summarized in Table (9).

In order to simulate the price, the patent cash flow fluctuation is equal to the average basket market volatility, based on information from the Intellectual Property Owners Association database of 16.96% and the average return of 11.76%. In the long run, the average cash flow is considered

Table 9: Patent specifications

Estimated annual cash flow in dollars	Cost of purchase of assets	Patent validity period (year)
60,000	399,000	10

equal to the prudent cash flow provided by the seller, and the average rate of interest is equal to 0.1 times the division of 1 by the number of years remaining in the patent. Using these assumptions, cash flow simulations have been carried out over the coming years, and Figure (2) shows the results of a one-time simulation of this process in the first year with 10,000 steps.

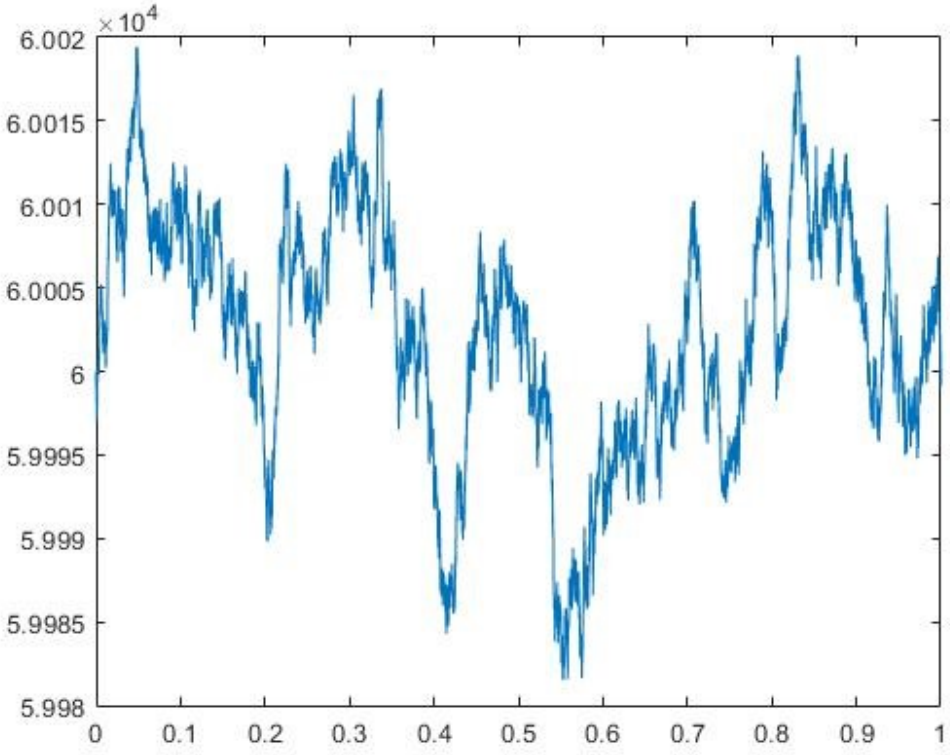

Figure 2: The first-year cash flow simulation results with 1000 steps

Cash flow simulations have been performed 1000 times a year to estimate cash flow and the resulting cash flows are divided into two scenarios: (1) cash flows less than expected and (2) cash flows more than expected. Then, for each scenario, the mean simulated values are inserted.

4.2.3. Patent valuation

This section evaluates the patent. For this purpose, the valuation assumptions table is first written and then the cash flows are drawn and the patent valuation is done. For the valuation of a patent, a number of assumptions for investing in a patent for an investor are set out in Table (10).

According to the assumptions mentioned in Table 9 and by simulating the patent cash flows in the preceding section, the project cash flows will be obtained in accordance with Figure (3).

Given the current value of the patent's cash flow (NPV), the current value of the project would be -54460 dollars, so investing in this patent would not be appropriate because the current value of the project's cash flow is less than zero.

Table 10: Patent specifications

Risk-free interest rate	This rate is equal to 2.83% for the US Treasury Bonds.
Lifetime patent	It is assumed that the patent buyer will use the patent for a maximum of 5 years and then sell it.
Depreciation	In this research the patent is 10 years old and is depreciated as a straight-line patent value.
Criterion of decision	Investments sell a patent if the expected cash flow (estimated cash flow) fails.

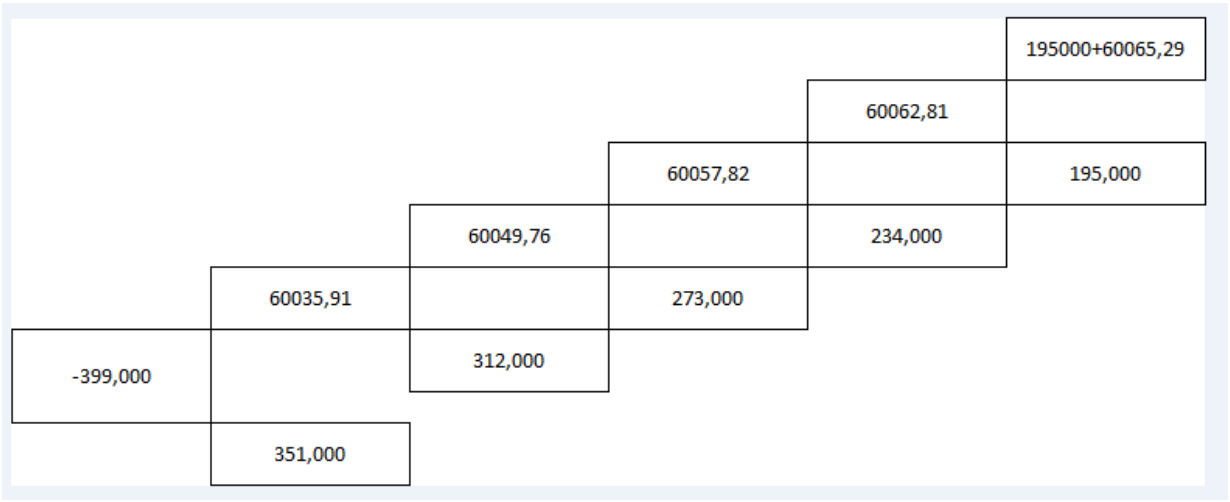

Figure 3: Patent 5-year cash flows

Table (11) shows the value of a patent by the traditional method, the method of genuine discretion. The difference in values obtained from these two methods shows the value of the option.

Table 11: Patent specifications

Price (USD)	**Real assistance value (Dollar)**	**Income value (USD)**
399,000	344,540	329,420
Option value		15,120

5. Conclusion

The purpose of this study was to develop a comprehensive patent valuation system. To this end, with previous research studies, the evaluation steps are summarized in two steps: (1) policy making and (2) valuation. In the first step of this research, a mechanism has been developed for deciding whether or not to invest in intellectual property. In this section, survey of Iranian stock market companies by stepwise regression showed that structural variables and human variables have no effect on firm profitability, while financial and customer-centric variables played an important role in the value creation of companies in Iranian stock market. finally, in the final part of the patent valuation with the so-called transfer of power and by simulating the patent cash flow, this result will provide the basis for the final management decision on whether or not to buy the patent.

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