

# ECONOMIC VALUATION OF PATENTS AS REAL OPTIONS

*Ing. Eva Kramna*

## **Abstract**

In today's high competitive business world it is for the successful firms necessary to manage not only their tangible property but also intangible assets. The main goal of this article is to approximate the application of real option methodology for patent valuation that takes into account the value of flexibility in investment decision making. In this paper is shown how to use real options methodology for valuation of patent. The theoretical background of real options is illustrated by the Black-Scholes model in the sample case adapted to Aswath Damodaran (Damodaran, 2001). This paper is completed by estimation of contemporary situation of patents granted by the Industrial property office in the last five years. The last part discusses in which situations make sense to use real options for valuation of patent and what are the most common problems of using real options.

*Key words in English: patents management, real options, investment decision, valuation, performance*

## **1 INTRODUCTION**

Intellectual property is the part of business assets. The valuation of intellectual property rights, specifically patents, has been one of the most difficult investment problems of managers. Patents represent investment opportunities.

Investment decisions are associated with long-term impact on business. It is therefore associated with higher risk and higher sums of money. The role of financial manager is to evaluate the effectiveness of the proposed investment. So far, the best known methods are based on projections of future cash flow that are compared with an estimated capital expenditure. These methods count with an idea that cash flows will be implemented for the whole time of project and do not take into account the possible changes that may have to occur during implementation. Therefore, nowadays become more valuable approaches that also include the possibility of change. Here managers can effectively use a method of real options. For a long time was not available a suitable tool that should reliably determine the relationship between the value of industrial property and the risk that the value losses or gains greater value. Currently, owner of licenses and those who want to invest technological solutions can behave as investors in financial markets. Patents give the owners a complex bundle of options. Managers can choose between exclusively commercializing the patented invention something during the patent term or foregoing commercialization altogether, for example they can use option to develop certain type of products, license the technology.

## **2 OBJECTIVE**

The objective of this paper is to approximate the theory and the application of real options methodology for patent evaluation. The basic intention is to describe theoretically Black-Scholes model and its variables for patent valuation. Considering patents are results of research and development, the key determinant of flexibility, the second objective is to show a descriptive analysis of contemporary situation of patent market in the Czech Republic. The third objective is to show a contrast between traditional valuation method (NPV) and real

options methodology that is illustrated by the sample case of evaluation of patent. Finally, it is discussed about application of real options a problem connected with their utilization.

### **3 METHODOLOGY**

Contribution by comparison of domestic and foreign literature review summarizes the methodology of real options and its possible use in the valuation of patents. The paper shows descriptive analysis of the current situation of patents in the Czech Republic. The main source of this analysis is official statistics website, articles, reports and analyses engaged in patents and real options methodology. The basic statistical data are used from reports and analyses done by the Czech statistical office, portal of the Research, Development and Innovation Council and other domestic and foreign information sources. For a large number of indicators, are chosen for analysis of valid licenses of patents only these that are granted in the Czech Republic. The patents are dividend according to various type of indicator. Finally, the application of real options methodology is demonstrated by using a model example. For calculation were used analytical method, especially Net present value and Black-Scholes model. This model is illustrated by the example adapted to Aswath Damodaran (Damodaran, 2001).

### **4 RESULTS**

#### **4.1 Application of real options**

In order to make effective use of real options in managing the company it is necessary to make a certain selection. The main aim is to eliminate those projects that will bring more expensive than benefit connected with them:

- investment decision connected with high risk and uncertainty when the option value is closed to zero,
- decisions that can't be postponed when additional information and right of election becomes meaningless,
- options for low-budget projects where the value exceeds the estimated capital expenditure.

Scholleová (Scholleová, 2007) presents that optional methodology should be used as a support tool for investment decisions, especially where operating factors such as:

- very uncertain future,
- wide range of managerial flexibility,
- NPV close to zero.

In the current turbulent times with the high competition in markets won't exist projects with a zero-risk and low levels of volatility will exist and most of them will have NPV close to zero. Real option will gain an important potential role. Van Puten and MacMillan (MacMillan, Van Putten, 2008) believe that to the value of each project should be minimally add value of the option to conclusion the project because there is always the possibility of abandon a failed project.

#### **4.2 Valuing a patent**

Black-Scholes model is lognormal model, in which the underlying assets price is assumed to be log-normally distributed, is still by far the most popular one. The Black-Scholes model applies when the limiting distribution is the normal distribution, and it explicitly assumes that there are no jumps in asset prices. This model was designed to value European options. This option-pricing model is rather difficult to be described.

The value of call option in the Black-Scholes model can be written as a function of the following variables:

$S$  = current value of the underlying assets

$X$  = strike price of the option

$T$  = life to expiration of the option

$r$  = riskless interest rate corresponding to the life of the option

$\sigma^2$  = variance in the ln (value) of the underlying asset

$y$  = dividend yield

The model itself can be written as:

$$C = S \times e^{-yT} \times N(d_1) - X \times e^{-rT} \times N(d_2) \quad (1)$$

where:

$$d_1 = \frac{\ln \frac{S}{X} + (r - y + \frac{\sigma^2}{2})t}{\sigma \cdot \sqrt{t}},$$

$$d_2 = \frac{\ln \frac{S}{X} + (r - y - \frac{\sigma^2}{2})t}{\sigma \cdot \sqrt{t}}.$$

Option to wait is used commonly for valuation of patent. This real option gives management right to postpone a time of an initiation of project of  $T$  years and to give and use for this time of postponing additional information about development of future based variables such as price of inputs and outputs, production volumes, market conditions. Although their value is known at the time of the decision but unstable that means that the acquired values can be capture by a certain probability expression. The management uses an option if the market conditions will be favourable for project.

It is a call option usually an American type however it can be especially European style. Basic parameters can be:

- **Patent's option price** (current price of underlying assets -  $S$ ) – the most frequent component of the patent option price is the fee associated with filing a patent application. An attorney or patent agent is usually hired to draft the application and due to increasing the price of purchasing the option. The price of the patent also includes the cost of creating the invention. The last component of option price is the benefits of trade secret protection that are lost.
- **Patent's exercise price** (realization price –  $X$ ) – exercising the patent option is usually focus on the commercialization of the underlying assets (invention) by the patent holder.
- **Patent's expiration date** (life of option –  $T$ ) – this date is initially tied to the expiration of the patent that expires by statute in 20 years from the filing date of the patent.

- **Patent 's risk-free interest rate ( $r$ )** – this rate is found out from the interest rate of the government bonds.
- **Patent 's volatility ( $\sigma$ )** – volatility is find is defined as the variance in the expected present value.

### 4.3 Patents and firm performance

Top management is participated especially in improving of the corporate's performance. To achieve growth in value it is need to know the so-called "Value Drivers" (Key Performance Indicators). Currently, there are many approaches and concepts of value management. Each of these approaches defines another factory significantly affecting value creation. The best known value concepts of performance management CFROI, Shareholder Value, EVA emphasize the importance of investment decisions such as tools of future growth opportunities. In the present strong competition it is important to be engaged in constantly maintain a competitive advantage as investment in more efficient use of technical quality allowing for better products or production of new types of products satisfying better to customer needs, further investment in research and development and human capital development, etc. Although the costs of the innovation require high initial costs are often a source of future increases in market value.

Innovation activity is often represented by count of patents. Bloom and Reenen (Bloom, Reenen, 2002) examine impact of patents on firm's performance. They discovered that patents have an economically and statistically significant impact of firm-level productivity a market value. The other finding was that while patenting feed into market values immediately it appears to have a slower effect on productivity. The last point of their research was finding of reduction of the impact of new patents on productivity caused by higher market uncertainty. The issue of valuating patents and their impact on firm's stock market values was also mentioned in the paper written by Pakes (Pakes, 1986). The literature engaged in important role of real options in firm's optimal investment strategies wrote (Dixit, Pindyck, 1994), (McDonadl, Siegel, 1986), and others.

The next part approximates the contemporary situation in patent market. The growing number of patents speaks positively of the growth of business interest in our market. The fact that only 29 % of owners of patents granted are domestic applicants does not however speak well of the appropriate development and appreciation of the significance of patent protection on the part of our companies and research and academic sphere. Foreign applicants have gained the dominant share of patents that are valid in the Czech Republic, especially 71 %. According to my opinion According to my opinion the Czech companies insufficiently protect their innovations. It means that in more European countries are innovations patented more often. The Czech companies should think about this problem and try to protect their know-how or other secrets that could help them to be better than their competitive firms. Patents granted by the Industrial property office (UPV) from 2005 to 2009 are shown in the bellow spreadsheet.

Tab. 1 - Patents Granted by the UPV. Source: The Czech statistical office

	2005	2006	2007	2008	2009
<b>Total</b>	<b>1 582</b>	<b>2 564</b>	<b>3 357</b>	<b>4 458</b>	<b>4 668</b>
Patents granted by the UPV	1 010	971	978	1 134	1 279
applicants from the Czech Republic	211	188	186	220	370
foreign applicants	799	783	792	914	909

<i>of which, international PCT applications</i>	605	610	602	761	760
---	-----	-----	-----	-----	-----

From the Tab. 2 is clear that the number of conferment of patents had an increasing trend. The most of the patent were granted in the three sections, chemistry and metallurgy, industrial technology, human needs. These three sections create more than 70 % of total granted patents. The others 30 % are equally divided into remaining sectors such as construction, electricity, mechanics, physics, textile and paper. It is right that Czech companies invest in the sectors in that they are in good level but they should evolve the other sectors too. The Czech companies could use programs and their accompanying subsidies to support science and research. This could lead to development of cooperation with domestic or international companies or with public scientific institutions and help with extending patents in all sectors.

Tab. 2 - Patents by International patents classification. Source: The Czech statistical office

	2005	2006	2007	2008	2009
<b>Total</b>	<b>1 582</b>	<b>2 564</b>	<b>3 357</b>	<b>4 458</b>	<b>4 668</b>
A Human needs	299	428	645	919	1 039
B Industrial technology, transport	431	733	867	1 240	1 086
C Chemistry; metallurgy	408	605	826	1 037	1 200
D Textiles; paper	27	74	82	127	149
E Construction	105	156	201	266	273
F Mechanics; lighting; heating, weapons	163	293	348	388	368
G Physics	66	136	182	220	241
H Electricity	83	139	206	261	312

#### 4.4 Relationship between patents and real options

Patent is a legal title granting its holder right to make use of an invention for a limited area authorization. The valuation of intellectual property rights, especially patents, becomes the most problems issues of managers. Currently they are used three approaches for estimating the economics benefit from patent: the cost-based approach, market-based approach and the income approach. Cost-based approach comes from relationship between cost and value of patents and ignores their future benefits. The fundamental of market-based approach is determination of patent value by using known transaction prices of comparable assets. The income approach is based on an estimate of hypothetical royalty payments one would have to pay to and third party to reap the benefits to patent. It uses the NPV rule that means that sum using DCF in the economic value of patents is often rejection of investment due to its higher risk and uncertain future payoffs. On the other hand it exist methods that may overcome limitation of traditional methods. The attention should be given to the valuation of real options. Real option is the right, not the obligation, to purchase the underlying asset at a defined exercise price. And patent is like a real options because it allows its owner to use of an invention at the predetermined cost, for a predetermined period of time (life of patent). This method improves the traditional approaches by including flexibility into manager's decision and gives them an ability to adapt its future plans to capitalize on convenient investment opportunities and also to respond to unfriendly development in a dynamic environment by cutting losses.

Dixit and Pindyck (Dixit, Pindyck, 1994) argued that most investment decisions have characteristics in terms of real options:

- investment is irreversible,

- uncertainty connected with the future return from the investment,
- managers have choice to invest at flexible time.

Extensive part of investment cost is sunk and cannot be recovered, such as patent maintenance fees and attorney's fees. However, it is impossible to determine optimal management of patents because of high risk that is connected with it. Patent is typical of great uncertainty over the future rewards from the invention. This profit is related with change of market condition and also it depends on the timing of investment in patented inventions because investing early in the process provides for earlier revenues stemming from patent. The real options theory specifies that firm's patent creates an irreversible investment opportunity that individuals or other firms cannot undertake. This investment opportunity is an American call option because investor may have an opportunity, but not the obligation, to undertake the project not only at a precise and given time, but also during a whole period of time. It gives managers the right to spend money now or in the future, in return for an asset of some value. According to the real options literature the optimal investment rule is based on assumption that asset value exceeds the investment cost by a potentially large option premium. The important advantage of the real option model is that managers are not constrained to make irreversible investment decisions but have flexibility to undertake different strategic decisions to respond to change of environment.

Sereno (Sereno, 2011) presents different type of real options, for example:

- **option to renew** – gives the owner the right to renew the benefits from a patent exploration for a maximum of 20 years or be dropped before the end of statutory patent life if it holder decides not to pay the relevant renewal fee,
- **option to license** – gives the owner the right to license the intellectual property when he does not possess the manufacturing and distribution resources necessary to produce and market the product on a national or even international scale,
- **option to abandon** – gives its holder the right to abandon patent before it expires by itself.

A few scholars have engaged in the valuation patents as real option. Denton and Heald (Denton, Heald, 2004) developed a state of the art method for valuing patents using financial options approach. Takalo and Kannianinen (Takalo, Kannianinen, 2000) present that impact of commitment to an R&D project is to create future options for patenting and market introduction.

In this section, we look at valuation of patent by using Black-Scholes model. The sample case is adapted to Aswath Damodaran (Damodaran, 2001). Product patent provides a firm with the right to develop and market a product. The firm will do so only if the present value of the expected cash flows from the product sales exceed the cost of development.

The biotechnology firm with patent on drug called "Avonex" that has passed to treat multiple sclerosis. As a basis we have following information:

- An internal analysis of the drug today, based on the potential market and the price that the firm can expect to charge, yields a present value of cash flows USD 3.422 billion, prior to consideration of the initial development cost.
- The initial cost of developing the drug for commercial use is estimated to be USD 2.875 billion if the drug is introduced today.

- The firm has the patent on drug for the next 17 year, and current long-term treasury bond rate is 6, 7 %.
- The average variance in firm value for publicly traded biotechnology firms is 0,224.
- In the day of the expiry of the patent may enter in the market any other entity with the same drug. Shortening of the patent thus reduces the price of the option. However, there is the option to wait for a higher yield. The company may be volatile due to the current value of waiting to get a higher yield but this yield is compensated by being less competitive advantage. This phenomenon is known as the “cost of delay”. These costs can be expressed by the following formula:

$$\text{cost of delay} = \frac{1}{n} \quad (2)$$

Cost of delay can be compared with stock options that bring dividends because without early exercise of the option the option holder do not receives dividends. For this reason will be used to estimate patent the Black-Scholes formula adjusted for dividends:

$$d_1 = \frac{\ln \frac{3422}{2875} + (0,0675 - 0,589 + \frac{0,224}{2}) \cdot 17}{9,4377 \cdot \sqrt{17}}$$

$$N(d_1) = 0,872$$

$$d_2 = \frac{\ln \frac{3422}{2875} + (0,0675 - 0,589 - \frac{0,224}{2}) \cdot 17}{9,4377 \cdot \sqrt{17}}$$

$$N(d_2) = 0,2076$$

$$\text{Patent value: } C = 3422e^{-0,0579 \cdot 17} \times 0,872 - 2875 \times e^{-0,067 \cdot 17} \times 0,2076 = 907$$

Contrast this result with the net present value of this project:

$$NPV = 3422 - 2875 = 547$$

Although the Net present value of the patent amounts only USD 547 billion Black Schools model evaluate patent for USD 907 billion. The higher price in this case means that the patent holder has the advantage of waiting for better market conditions. So for an investor it is better to wait. Shorter time to the end of patent life will decline its value because it will increase the cost of delay. A further factor will also reduce factor T.

As we see from this example, patent valuation using real options has led to a higher value than using NPV. The effect would be even more visible if the NPV is zero or even negative. Real option pricing models can therefore be better unlike traditional methods to determine the intangible assets based on the benefits of bringing the asset owner.

## 5 DISCUSSION

Many economists have a question if patents are really options? The problem is a difficult answer if the methods of real options is used right to evaluation of patents. The correct

methodology is generally considered, in principle, any methodology that has at least outwardly somehow justifiable procedure.

Authors concede that patents can be considered as options in the sense that the owner offers the following options:

- options to prevent others to use technical solutions,
- options to acquire additional assets or take advantage of their complementary assets to the value of innovation.

Kidder and Moody (Kidder, Moody, 2003) find that patents for first look can be really valuate as option. Managers that use real options theory to valuation of patents link up patent's value with value of underlying assets that is often project of new product development to which they are applied technical solutions protected by patents. By this way managers get inputs of Black-Scholes model. Authors see a lot of problem why managers should not use option methodology to valuating patent. They foreshadow that it could be used to determine the value of the patent and the theory of real options but the used methods should be much more comprehensive way than the Black-Scholes formula.

On the other hand a lot of scholars use real options methodology in their research work. For example Meng (Meng, 2008) uses a continuous time real options approach to develop a duopoly patent race model or Bloom and Reenen (Bloom, Reenen, 2002) analyzing database on over 200 firms where they show that patents have an economically and statistically impact on productivity and market value by using real option model. Takalo and Kanninen (Takalo, Kanninen, 2000) found out that patents always speed up technological progress and create future options.

Problem in learning how to use real options consider Copeland and Kenan (Copeland, Kenan, 1998) to be caused by disability to recognize them in real-life managerial settings. They lost management's flexibility to alter the course of a project in response to changing market condition. The most common problem of using real options is following:

- complexity of using basic tools,
- short time of beginning real options methodology at university lead to the small extent,
- insufficient awareness of the need for flexibility in the use of evaluation and detention of its value to the volatility,
- inadequate tools for quantification of some parameters of assessment, primarily volatility.

## **6 CONCLUSION**

The use of new economic approaches to describe the patents is nothing new. Real options theory provides a similar opportunity. This article gives an overview of the real options theory and its application to the valuation of the patents. In this paper is mentioned an importance of patents to the firm's performance. Patents have an economically impact on firm's productivity and market value. Impact of new patents on productivity reduces higher market uncertainty. The theoretical background is applied on the most famous valuation model of real options, the Black-Scholes model. This model is illustrated by the example adapted to Aswath Damodaran (Damodaran, 2001). This model shows that patent valuation using real options has led to a higher value than using NPV. This fact stems from the fact that the flexibility that gives the patent holder's value. For completion information is shown the current situation of patents in the Czech Republic.

Managers use a range of methodologies including earnings per share or economic profit, discounted cash-flow, etc. However, in the situations of high uncertainty where management



can respond flexibly to new information and where the NPV is close to zero is favourable to use real options. Real options approach becomes more valuable because it can capture the value of managerial flexibility in a way that NPV analysis does not. Real options analysis could add a dimension to the theory of patents focused on their private value, instead on their social value.

## 7 BIBLIOGRAPHY

### References

1. BLOOM, N., Reenen, J.V. Patents, real options and firm performance. *The Economic Journal*, 2002, vol. 112, pp. 97-116.
2. COPELAND, T.E., KEENAN, P. How much is flexibility worth? *The McKinsey Quarterly*, 1998, vol. 2, pp. 38-49.
3. COTROPIA, CH.A. Describing patents as real options. *Journal of corporation law*, 2009, vol. 34, pp. 1127-1149.
4. CZECH STATISTICAL OFFICE [online]. c2011 [cit. 2011-02-05]. CSU. Dostupné z WWW: <[http://www.czso.cz/csu/redakce.nsf/i/patentova\\_statistika](http://www.czso.cz/csu/redakce.nsf/i/patentova_statistika)>.
5. DAMODARAN, A. *The Dark side of valuation: valuing old tech, new tech, and new economy companies*. Upper Saddle River, NJ: Prentice-Hall, 2001. ISBN 0-13-040652-X.
6. DENTON, R., HEALD, P.J. Random walks, non-cooperative games and the complex mathematics of patent pricing. *Rutgers law review*, 2004, vol. 55, pp.1175-1188.
7. DIXIT, A.K., PINDYCK, R.S. *Investment under uncertainty*. New Jersey: Princeton, 1994. ISBN 0-691-03410-9.
8. DLUHOSOVA, D. *Finanční řízení a rozhodování podniku: analýza, investování, oceňování, riziko, flexibilita*. Praha: Ekopress, 2008. ISBN 978-80-86929-44-6.
9. EUROPEAN COMMISSION. *Science, technology and competitiveness: key figures report 2008/2009*. Directorate General Research – European research area – Knowledge Based Economy, 2009. ISBN 978-92-79-10173-1.
10. KIDDER, D., MOODY, N. Are patent really options? *Les Nouvelles*, 2003, p. 190.
11. MACMILLAN, I., VAN PUTTEN, A. *Unlocking opportunities for growth*. US: Peason Education, 2008. ISBN: 0-13-2237-90-3.
12. MALÝ, J. *Oceňování průmyslového vlastnictví: Nové přístupy*. Praha: C.H.Beck, 2007. ISBN 978-80-7179-464-6.
13. MCDONALD, R., SIEGEL, J. The value of waiting to invest. *Quarterly journal of economics*, 1986, vol. 101, pp. 707-727.
14. MENG, R. A patent race in real options setting: Investment strategy, valuation, CAPM Beta and Return volatility. *Journal of Economic Dynamics and Control*, 2008, vol. 32, pp. 3192-3217.
15. PAKES, A. Patents as options: some estimates of the value of holding European patents stocks. *Econometrica*, 1986, vol. 93, pp. 755-784.
16. SERENO, Luigi. *Real options and Economic valuation of patents*. [online]. [cit.2011-02-01]. Dostupný z WWW: [http://www.evpat.net/down/REAL\\_OPTION\\_AND\\_ECONOMIC\\_VALUATION\\_OF\\_PATENT.pdf](http://www.evpat.net/down/REAL_OPTION_AND_ECONOMIC_VALUATION_OF_PATENT.pdf)>.
17. SCHOLLEOVÁ, H. *Hodnota flexibility-Reálné opce*. Praha: C.H.Beck, 2007. ISBN 978-80-7179-735-7.
18. SCHWARZ, E.S. Patents and R&D as Real options. *Economic notes*, 2004, vol. 33, pp. 23-54.

19. SMEJKAL, A. Real options in investment decision-making. In *Sborník příspěvků z mezinárodní vědecké konference INPROFORUM 2007*. 1. vyd. České Budějovice: Ekonomická fakulta, Jihočeská univerzita v Českých Budějovicích, 2007. pp. 631-636. ISBN 978-80-7394-016-4.
20. TAKALO, T., KANNIAINEN, V. Do patents slow down technological progress? Real options in research, patenting, and market introduction. *International journal of industrial organization*, 2000, vol. 18, pp. 1105-1127.
21. TRIGEORGIS, L. *Real Options in Capital Investment: Model, strategies and applications*. Westport: Praeger, 1995. ISBN 0-275-94616-9.

### **Contact information**

Ing. Eva Kramná

Tomas Bata University in Zlín, Faculty of Management and Economics

Mostní 5139, 76001 Zlín, Czech Republic

Tel: +420 576 032 417

Email: [kramna@fame.utb.cz](mailto:kramna@fame.utb.cz)