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Streszczenia

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REAL OPTION APPROACH TO EQUITY VALUATION

Summary: The paper presents an option approach to the valuation of equity as an alternative to the method based on the discounted cash flows valuation. In the first part of the paper, the essence and the basic types of real options as well as valuation models are presented. Then the article explains how to treat the equity as a European call option issued on the value of the entire enterprise, where issuers are creditors and option holders are shareholders. The last part of the article includes a case study that explains the impact of risk and other factors on the value of equity and illustrates the valuation of equity using the Black-Scholes option pricing model.

Keywords: equity valuation, real option.

1. Introduction

Valuation of company's equity by means of the discounted cash flow method requires a lot of analyses and financial projections. Due to the fact that equity owners are entitled to future cash flows in excess of all financial obligations, equity can be considered as an option to buy the whole company. Writers of such options are creditors, whereas buyers are owners, who have flexibility in their decision-making process and may acquire rights to a company if its value exceeds the total debt. This means that for the purposes of equity valuation, it is possible to apply the model for stock option valuation. The equity of a company is therefore seen as a specific type of real option.

The objective of this paper is to present the possibility of valuing equity using the option pricing method on the background theory of real options valuation. Research problem addressed in the paper concerns the question of whether the option pricing model may be applied to estimate the value of equity and to answer the question of the relationship of this value with the risk of doing business. The thesis of the article is a stipulation that the value for owners, like the financial value of a call option, is positively dependent on the risks associated with running a business. This means that managers can increase the market value of equity and reduce the value of debt, assuming that the total value of a company held constant, by undertaking very risky investment projects. In the paper logical reasoning as well as explanatory case study are used. The presented case study is basically a numerical example, which can be

treated in economics as the equivalent of an experiment in the natural sciences, such as physics.

2. The essence of real options

The term "real option" was first used in 1977 by S.C. Myers from Massachusetts Institute of Technology. This concept was then developed in the 1980s by A.K. Dixit and R.S. Pindyck. The first application of real option took place mostly in industry oil, gas and the extraction of copper and gold. However, the source of this theory had a beginning in the early 1970s, when M. Scholes, R. Merton and F. Black laid the foundations for the valuation of financial options [Borison 2005, p. 17] .

A real option can be defined using the analogy to financial options. It is therefore the right of its holder to buy or sell an underlying asset (underlying instrument, which can be the investment project or the whole company) in a specific size, at a fixed predetermined price and the specified time in the future. Generally, it can be said that a real option is the right to modify the investment project in an enterprise [Brealey, Myers 2003, p. 269].

Real options are very effective tools, because – according to Triantis, Borison [2003, p. 106] – they recognize that future decisions designed to maximize value will depend on new information, such as changes in financial prices or market conditions. The point is that, like the value of the financial option depends on the future stock price, the value of real options is dependent on the future value of an underlying real asset, that is, the future value of investment project or the whole company.

The classification of real options can be based on two basic criteria. The first relates to the specific types of real options, the latter is related to the finding in the design of real options analogy to financial options.

Taking into account the first criterion, one can distinguish five basic types of real options [Nita 2007, pp. 172-173]:

An option to delay that allows postponing the start of an investment project. The positive net present value of a project does not always mean that managers should immediately begin the investment process; sometimes it is worth waiting and analyzing the changes in the market. On the other hand, the negative NPV of a project does not rule immediately on the chances of its implementation, because in the future a project can be effective and demonstrate a positive NPV. An option to delay is a law to delay the start of a project and to establish such a moment that will be most beneficial for a company.

An option to expand is the right to expand the scope of an investment in the future. A company may invest in certain projects today, because in the future this will allow undertaking new investment projects. Therefore, sometimes it pays to accept projects that are currently NPV negative, since it makes it possible to obtain the future benefits of projects with high positive NPV. An option to expand is the right to develop future activity of a company.

1. An option to abandon is the right to withdraw from an investment project at the occurrence of unfavorable market conditions for a company. It allows managers to stop a project if projected cash flows do not meet the expectations of investors. This kind of option may be also explained as the right to sell certain assets at a predetermined price that reflects the residual value (salvage value).

2. A flexibility option, in the most general terms, is an option that allows customizing the production process to market conditions and benefiting from favorable circumstances, mainly related to the changes in prices. It can be seen as the right to take flexible operations involving the increasing or reducing scale of operations, relocation, or plant startup or shutdown, depending on demand and prices.

3. A staging option gives the right to incur capital expenditures in the subsequent stages. It means the right to postpone a project until managers receive more detailed information on the potential attractiveness of the investment project under consideration.

In practice, economic activity of a company may be characterized by a bundle of many different options. Such a portfolio of options (multiple interacting options) requires a detailed identification and analysis of all options and their valuation. Sometimes, the value of such a portfolio is different from the sum of the individual components of the options [Trigeorgis 1998, p. 3].

The second classification of real options can be made due to the analogy to standard types of financial options. As for the kind of right arising from an option, one can distinguish an option to buy (call option) or an option to sell (put option), but with regard to the expiration date there are American options (allow the owner of the option to exercise it at any time before it expires) and European options (can be exercised only on its expiration date).

3. Option valuation

Decision-making flexibility, resulting from the possibility of the modification of a project in the future, causes right-hand asymmetry of the probability distribution of net present value NPV. This means that the actual value of investment opportunities rises by increasing the upper potential for creating value, while the lower limit of occurrence. If the owner of an option does not have decision-making flexibility, the probability distribution of NPV is symmetric, which means that the static NPV, without any real option embedded in a project, coincides with the expected value of the distribution. Thus, the value of the investment project, taking into account the right to modify the project in excess of the value of the project without decision-making flexibility, is the value of this flexibility. This relation can be written as follows [Trigeorgis 1998, p. 124]:

Expanded (strategic) net present value (NPV*)

=

Standard (static, passive or direct) net present value of expected free cash flows (NPV)

+

Option premium (value of operating and strategic options from active management and interaction effect of competition, synergy, and inter-project dependence).

In order to define a strategic NPV*, taking into account decision-making flexibility, real options embedded in an investment project should be valued. Real option value, as in the case of financial options, depends on five key factors:

1) the exercise price,
2) the prices of an underlying instrument,
3) the length of time to expiry,
4) the percentage rate of return on risk-free,
5) the volatility of an underlying instrument.

The value of an option increases when the time to expiration increases, risk-free rate goes up, the level of risk for a given project increases, and finally the value of an underlying project increases. Exercise price has the opposite effect on the call option value – the higher price, the lower the value of an option.

For the purposes of valuing real options, two models can be applied:

1) the binomial model by J. Cox, S. Ross and M. Rubinstein,
2) the Black-Scholes Option Pricing model.

The basic assumption behind the binomial model is that changes in asset prices occur in a discrete way. The most general binominal model assumes that the present value of future cash flows in each period can increase or decrease depending on market conditions (e.g., due to low or high demand). Assuming the valuation under risk-free conditions, it is possible to estimate the probability of growth or decline in the price of underlying assets in each period and thus determine the value of an option.

The option pricing model proposed by F. Black and M. Scholes, in contrast to the binomial model, is based on the assumption that changes in asset prices are continuous. The basic Black-Scholes formula of pricing European call options written on stocks is determined by the following equations:

$$V = P \cdot N(d_1) - E \cdot e^{-r_{RF}t} \cdot N(d_2), \tag{1}$$

$$d_1 = \frac{\ln\left(\dfrac{P}{E}\right) + \left(r_{RF} + \dfrac{\sigma^2}{2}\right) \times t}{\sigma \times \sqrt{t}}, \tag{2}$$

$$d_2 = d_1 - \sigma\sqrt{t}, \tag{3}$$

gdzie: V –   a call option value,

$\quad\quad P$ –   the price of an underlying instrument,

$\quad\quad E$ –   the exercise price,

$\quad\quad r$ –   a risk free rate,

$\quad\quad t$ –   the length of time until the expiration date,

$\quad\quad \sigma^2$ –   the variance of an underlying instrument,

$\quad\quad N(d)$ –   the value of the distribution function of standardized normal distri-
bution for the argument d.

Key assumptions of the Black-Scholes option pricing model are the following (see Brigham, Daves [2010, p. 203]; Jajuga, Jajuga [1999, p. 197]):

1) the stock underlying a call option provides no dividends or other distributions during the life of the option,

2) there are no transactions costs for the sale/purchase of either a stock or an option.

3) risk free rate is known and constant during the life of an option,

4) any purchaser of a security may borrow any fraction of the purchase price at the short-term, risk-free interest rate,

5) short selling is permitted and short sellers will receive immediately full cash proceeds at today's price for a security short sold,

6) a call option can be exercised only on its expiration date,

7) trading in all securities takes place in continuous time, and stock prices move randomly in continuous time.

The derivation of the Black-Scholes model is based on the concept of a riskless hedge. A call option is an equivalent to a levered position in the stock where the number of shares of the stock held in the replicating portfolio is given by $N(d_1)$, and the amount borrowed is given by the second term [Trigeorgis 1998, p. 91].

4. Equity as an option on corporate value

Equity can be seen as the right to the cash flows generated by a company in the future, which will remain in excess of all liabilities. This right can be valued in a similar manner as the financial call option. Writers of a call option are debtholders, whereas owners are treated as buyers. In other words, at the time of having debt, owners "sell" a company to creditors, while preserving the right of redemption. Owners exercise the option at maturity of debt only if an enterprise value exceeds the value of debt [Mizerka 2005, p. 218].

The valuation of company's equity is often carried out using the income approach based on discounted cash flow balances. The value of equity can be also optionally measured using the approach. In this perspective, equity can be seen as a call option issued on the total value of a company. The value of equity is the difference between the total value of a company and the value of debt. Thus, if the total value of a company exceeds the value of company debt, owners will receive the sur-

plus and option is in-the-money. However, in the opposite case, if the value of company's debt is greater than the total market value of a company, this company will become bankrupt and its owners will not receive anything. In this case the option is out-of-the money. The function of payments to shareholders can thus be explained as in Figure 1.

Corporate value		Debt		Payoff to owners
if	**V**	**>**	**D**	then	**V − D**
if	**V**	**<**	**D**	then	**0**
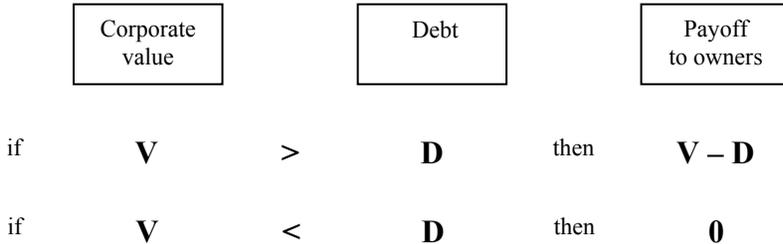
Fig. 1. Payoff to stockholders from an option

Source: author's own work.

The payoff to owners reflected in Figure 1 is the same payoff as the European call option on the total value of a company. Table 1 depicts factors affecting the value of such an option that are analogous to the drivers of a call option on stock.

Table 1. Factors affecting the value of financial options and real options

Financial call option on stock	Equity as an option on corporate value
Stock price	Total value of a company
Exercise price	Par value of debt
Time to expiration of a stock option	Maturity of debt in years
Standard deviation of a stock price	Standard deviation of the total value of a company
Risk free rate	Risk free rate

Source: author's own work.

For the purpose of the valuation of equity as a call option, the market asset disclaimer approach can be addressed.[1] This approach generally assumes that an underlying instrument is not correlated with a financial instrument, but is treated as an independent financial instrument. The MAD approach is not based on the existence of a traded replicating portfolio. This approach takes the static NPV as the market

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[1] See Copeland, Antikarov [2003] for further elaboration.

value of a project. According to T. Copeland and V. Antikarov, the first step in the MAD approach is to build a spreadsheet cash-flow model of an underlying investment using subjectively estimated inputs, and calculate its NPV using a CAPM-based discount rate. Second, they recommend subjectively estimating the uncertainty associated with inputs to this model and conduct a Monte Carlo simulation of the model. Finally, the resulting distribution should be used to build a risk-neutral binominal lattice on the basis of Geometric Brownian Motion (GBM) and estimate the option value using this lattice.

There are two basic problems with the MAD approach. The first stems from the MAD assumption that means the value of an underlying investment should be assessed subjectively. This assumption ignores the possibility that there might be a replicating portfolio for a corporate investment or that important elements of an investment, such as prices, might have market equivalents. The second problem stems from the GBM assumption, because there is no reason to believe that a subjective valuation of an underlying investment should follow GBM. In fact, the value of underlying investments may be driven by specific events in specific time periods in a manner that looks nothing like "random drift" [Borison 2005, p. 24].

The option approach to equity valuation is increasingly recommended in the literature. However, three basic problems should be noted.

First, the use of the Black-Scholes model requires a number of assumptions. These assumptions are not necessarily satisfied with the valuation of the equity of a company and moreover some of them may be subjective. For example, standard deviation estimation requires the opinion of experts or an in-depth quantitative analysis.

Secondly, the valuation of equity requires additional assumptions that go beyond the set of assumptions adopted for the valuation of real options. Generally, these additional assumptions may refer to the total value of a company and debt. After all, the Black-Scholes model was originally used for the valuation of financial options without any special applications.

Thirdly, one of the most important principles of corporate valuation means that the valuation process cannot be confined to only one method. This is also a consequence of the subjectivity previously discussed. Therefore, there is a need for a treatment option approach as an alternative approach or to treat this method as a complement to other approaches. One of the most important valuation approaches is the income approach based on discounted cash flows. It should be noted that compliance cannot be expected mainly due to the different assumptions of both approaches. The discounted cash flow method is in fact a fundamental approach and requires a lot of assumptions.

5. Case study

The objective of this case study is to explain the process of equity valuation using the real option approach. For the purpose of this case study, it is assumed that the total

value of ABC Company is 64 million PLN. This amount is the sum of debt and equity. It is also assumed that the company liabilities include four-year zero coupon bonds with a nominal value of 30 million PLN. Risk-free year is about 5%, and standard deviation that represents volatility of all assets is 0.45.

The equity of ABC Company may be perceived as a European call option on the total value with a strike price of 30 million PLN that expires in four years. If the total value of ABC Company is less than 30 million in four years, then the company will not be able to pay off its debt. As a result, the company will go bankrupt and be liquidated or sold, and the debtholders will get the total value and the stockholders will get nothing. If the company is worth more than 30 million, then the managers will be able to pay off debt and the owners will keep the ABC Company.

The value of the option can be calculated with the Black-Scholes Option Pricing Model described by means of Formula (1). The basic factors affecting the value of the option in this case are: total value of the company ($P = 64$ million), the nominal value of the debt that is an exercise price ($E = 30$ million), the maturity of the debt that is the option's time to expiration (4 years), standard deviation of the total value of ABC Company (0.45), and risk-free rate (5%). Required inputs with Formulas (1) and (2) are computed in the following way:

$$d_1 = \frac{\ln\left(\dfrac{P}{E}\right) + \left(r_{RF} + \dfrac{\sigma^2}{2}\right) \times t}{\sigma \times \sqrt{t}} = \frac{\ln\left(\dfrac{64}{30}\right) + \left(0.05 + \dfrac{0.2025}{2}\right) \times 4}{0.45 \times \sqrt{4}} = 1.5141,$$

$$d_2 = d_1 - \sigma\sqrt{t} = 1.5141 - 0.45 \times \sqrt{4} = 0.6141.$$

The value of the European call option on total value of the company is the following:

$$V = P \cdot N(d_1) - E \cdot e^{-r_{RF}t} \cdot N(d_2) = 64 \cdot 0.9350 - 30 \cdot e^{-0.05 \cdot 4} \cdot 0.7304 = 41.9.$$

It turns out that the equity of ABC Company is worth 41.9 million PLN, and consequently the debt of the company is worth the difference between the total value and the value of equity:

$$PV(D) = 64.00 - 41.90 = 22.1 \text{ million PLN}.$$

The current value of debt is then 22.1 million PLN. It is now possible to derive the yield on debt:

$$i = \left[\frac{FV(D)}{PV(D)}\right]^{\frac{1}{t}} - 1 = \left[\frac{30}{22.1}\right]^{\frac{1}{4}} - 1 = 7.939\%.$$

In this case study, the present value of the debt issued by ABC Company is 22.1 million PLN, and the debt is yielding 7.94%. Obviously, the yield on the debt is greater than risk-free rate of return of 5%. This is because the bonds issued by the company are risky and the company may go bankrupt if its value goes down.

Table 2. Sensitivity analysis of debt and equity on volatility

Volatility	Equity	Debt	Debt yield (%)
0.20	39.48	24.52	5.17
0.25	39.64	24.36	5.35
0.30	39.98	24.02	5.71
0.35	40.48	23.52	6.28
0.40	41.13	22.87	7.03
0.45	41.90	22.10	7.94
0.50	42.75	21.25	9.00
0.55	43.66	20.34	10.20
0.60	44.60	19.40	11.52
0.65	45.57	18.43	12.96
0.70	46.55	17.45	14.51
0.75	47.53	16.47	16.17
0.80	48.50	15.50	17.94
0.85	49.45	14.55	19.83
0.90	50.38	13.62	21.82
0.95	51.28	12.72	23.92

Source: author's own work.
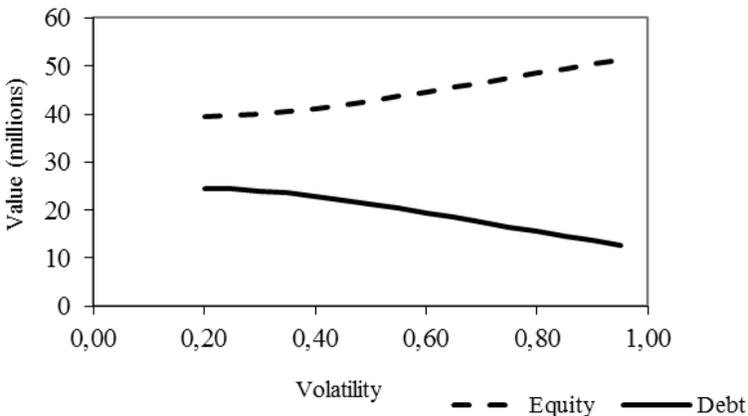
Fig. 2. The value of debt and equity for various levels of volatility

Source: author's own work.

Generally, the higher volatility, the more option is worth and the higher value of equity. If the managers of ABC Company are able to increase the riskiness of the company without decreasing its total value, it will increase the value of equity while decreasing the value of the debt. Table 2 presents the sensitivity analysis that explains the relationship between the standard deviation of the company's total value and the value of equity, debt and the yield of debt.

On the basis of the sensitivity analysis, Figure 1 was prepared. Figure 2 shows that managers may increase value of equity and simultaneously decrease value of the debt by choosing risky investment projects. If volatility of an undertaken project increases from 0.45 to 0.90, then the 20.2% increase in equity value is observed (from 50.38 to 41.90 million PLN).

If the financial performance of ABC Company was not that good and the total value was only 32 million PLN, that is, half of the initial value, sensitivity of the equity value on the volatility would be greater. It may be examined easily that when ABC total value was only 32 million PLN and it has issued four-year zero coupon bonds of 30 million PLN face value, its equity would be worth 13.93 mln PLN with a standard deviation of 45%. Increasing volatility to 90% would increase the equity value to 21.73 million PLN, that is, by 56%.

6. Summary

On the basis of the above considerations and the described example, it has been shown that the option approach may be applied to the value equity of a company. This analysis is especially important from the point of view of various claimholders. The higher the volatility of a company, the higher the value of equity, the higher probability of default and consequently the lower value of debt and obviously the higher yield on debt. Moreover, the longer the maturity of debt and the higher the risk-free rate of return, the lower the present value of debt. Generally speaking, if the total value of a company increases, the probability of going bankrupt decreases. Taking into account that claims on debt are complementary to the claims on equity, these factors influence the value of equity in the opposite manner. As a result, a potential conflict arises between stockholders and debtholders. By issuing bonds, stockholders give ownership of total company's assets to debtholders. If stockholders maintain a call option, they have the right to buy back the entire company with an exercise price equal to the face value of debt.

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PODEJŚCIE OPCJI REALNYCH DO WYCENY KAPITAŁU WŁASNEGO PRZEDSIĘBIORSTWA

Streszczenie: Opracowanie przedstawia podejście opcyjne do wyceny kapitału własnego jako alternatywę dla metody dochodowej opartej na dyskontowaniu przepływów pieniężnych. W pierwszej części opracowania zaprezentowano istotę i podstawowe rodzaje opcji realnych oraz podstawowe modele wyceny. Następnie wyjaśniono rozumienie kapitału własnego jako europejskiej opcji kupna wystawionej na wartość całego przedsiębiorstwa, gdzie wystawcą są wierzyciele, a posiadaczami opcji akcjonariusze. Ostatnia część artykułu obejmuje studium przypadku, które wyjaśnia wpływ ryzyka i innych parametrów na wartość kapitału i stanowi ilustrację wyceny kapitału własnego za pomocą modelu Blacka-Scholesa.

Słowa kluczowe: wycena kapitału własnego, opcja realna.