NÁRODNÁ BANKA SLOVENSKA

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In 1997 the Nobel Prize for Economics was awarded to two distinguished American economists from the field of financial theory – Robert C. Merton and Myron S. Scholes. The prize was granted to them for the original theoretical contribution in the field of derivative pricing - i.e. pricing of securities that are derived from other

assets – whether financial or real. In our article we focus on one of the two – Myron S. Scholes, who became famous in the financial world primarily as the co-author (together with Fischer Black) of the model for option pricing. This model is the "classic" instrument of financial analysts as well as financial market traders.

Myron S. Scholes was born on 1 July 1941 in the town of Timins in the Ontario province, Canada.

The young Myron always had an interest in financial issues and business. He was attracted to security trading. He spent much time studying stock-exchange reports and attempted to understand the secrets lying behind price movements of securities. Myron Scholes began university studies in Hamilton at McMaster University, graduating from undergraduate studies in 1961. He later continued his studies at the University of Chicago, where he was attracted by leading lights in economic science, such as George Stigler and Milton Friedman.

In the first year of studying at the University of Chicago M. Scholes began to work, alongside his studies, as an assistant for computer programming. Computer science had become his great love. He helped to solve programming tasks for many important personalities – including, for example, M. Miller and E. Fama[1], where he was also very interested in their theoretical approaches and objectives. In the end this was to significantly contribute to the formation of Scholes' research orientation. The concept of an efficient capital market actually provides a background to all his works.

Scholes was interested primarily in issues of pricing securities and the role of arbitrage[2], which should limit the attainment of extraordinary profits by inducing a tendency for a mutual approximation to occur in the prices of securities having the same degree of risk.

At the time when he was completing his Ph.D. dissertation (1968) Scholes began teaching at the Sloan School of Management, MIT, where he had the possibility to work with many other leading theoreticians from the field of finance. It was here that his cooperation with Fischer Black and Robert Merton began (even though they worked in different institutions). These economists were also interested in issues of the security and derivative pricing. Scholes still at the same time maintained his contacts with the University of Chicago, in particular with the Center for Research in Security Prices. They gathered a huge amount of data on the development of security prices, which helped him also in creating a theoretical model.

In the 1980's Scholes worked at Stanford University, first as a visiting and later as a full professor. His research orientation at that time broadened to cover other issues: the effect of taxes on the security pricing and on the dividend policy of corporations, issues of pension funds and investment banking, issues of the tax planning of corporations in conditions of uncertainty[3], etc.

In the 1990's Scholes' theoretical and practical interest shifted back to the field of pricing of securities, in particular derivatives. Even though a popular article on the option pricing (the Black – Scholes Model) was published at the start of the 1970's, the 1990's represented a period of their practical application and the theory's further development. In 1994 Scholes became a co-founder of the famous investment fund Long-Term Capital Management (LTCM)[4] and in 1996 gave up his post as professor at Stanford University in order to fully devote himself to managing this fund. Following the crash of the LTCM fund he has dealt in particular with theoretical questions of liquidity and the influence of large shocks on the capital market, as well as conducting consultancy activity.

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[1] Profiles of both famous economists who entered into economics history primarily through their theory of the capital market were published in the BIATEC journal, 2002 no. 8 and 2003 no. 3.

[2] Arbitrage on the security market means the purchase of one security and concurrently the sale of another with comparable risk, if over the short-term price differences exist.

[3] These issues are included in the book Scholes, M. S.- Wolfson, M. A.: Taxes and Business Strategies: A Planning Approach. Prentice Hall 1991.

[4] The activity of LTCM and its crisis will be covered in the 3rd part of this article.

The Black – Scholes option pricing model

Myron Scholes became popular in the financial world primarily due to his option pricing model, which he published jointly with Fischer Black in 1973.[5] This model was the outcome of many years' research work, supported by a huge quantity of data on the development of security prices.

Options are securities that give their holder the right to purchase (a call option) or sell (a put option) a certain quantity of securities, or possibly other assets at a future date at a price agreed in advance. The holder of the option may exercise this right, but does not have to if such a sale would be disadvantageous for him. If, for example, the market price of the share at the time of the option's expiration is lower than the agreed realisation price, there is no reason to exercise the call option. Likewise, if the market price at the time of a put option's expiration is higher than the realisation price, there is no reason to realise this option. In the case of so-called European options, an option may be exercised only at the maturity date, a set date. In the case of American options the option may be exercised any time in the period up to maturity.

Transactions in options require two parties (partners). In order for the holder of an option to be able to exercise his right, there must be a second party that is obliged to sell the shares to or buy them from the first at the agreed price. This second party is termed the option issuer. This party bears the risk connected with the fluctuation of market prices. Therefore it has a claim to a certain premium for the risk, which the party buying the option (the holder) must pay to it. The option holder's risk is substantially lower. Essentially it can lose only the amount it paid for the option. Therefore options are treated as one of the forms of hedging against risk.

How can the level of this premium, i.e. the option's price, be correctly set? In the huge and rapidly growing volume of option trades such a question is of great importance. At first glance it is clear that the option value (price) depends on the price of the underlying asset – at the time of concluding a contract – and also on the fluctuation of this price up until the option's maturity (expiration). Investors acquiring shares by means of call options are in fact buying on credit. They pay the price of the option today, but pay the option exercise price only when they actually exercise the option. Deferral of the payment is particularly valuable if interest rates are high and an option has a long term to maturity. Therefore the value of the option rises also with the interest rate as well as with the length of time to expiration. The Black – Scholes model includes all these basic factors. At the same time it works from certain simplifying premises, namely:

- During the life of an option no dividend is paid out on the stock for which the options have been issued,
- An efficient capital market exists,
- The interest rate is known and does not change during the option's life. This rate is used for discounting future yields.
- It is abstracted from the fees for the purchase or sale of options (from transaction costs).

The basic Black-Scholes model can be mathematically expressed as follows:

$$C = Sd^{-t}N(x) - Kr^{-t}N(x - \sigma\sqrt{t}),$$

$$\text{where} \quad x = [\log(Sd^{-t}/Kr^{-t}) + \sigma\sqrt{t}] + {}^{1}/_{2}\sigma\sqrt{t}$$

and where:

C = the value of the call option
S = current value of the asset (for example a share), for which the option has been issued
t = the time to expiration of the option (in years)
K = the agreed (exercise) price
r = the interest rate on risk-free securities
d = the annual yield on securities
N = the cumulative normal distribution of yield probability
s = standard deviation of the annual rate of the yield on the stock

The basic idea of the model is that the price of options should equal the difference between the present value of the expected price of the asset (e.g. a stock) at expiration and the present value of the realisation price, where each of these variables is weighted by their probability distribution (in the range 0 – 1).

The restrictive premises of the model were later lessened. For example, R. Merton created models taking account also of dividends and changes in interest rates. The Black – Scholes model is perhaps the most cited model in financial literature. Software has been created for its practical use, and functions for calculating the value of options according to this model are built into financial calculators. According to Scholes' ideas the basic aim of financial theory is to contribute to simplifying and making more efficient the process of financial decision-making. The model undoubtedly fulfils this function. The model's publication was also well timed; the Chicago Board Options Exchange opened for trading at roughly the same time.

The world as a laboratory for testing theoretical models

The title of this part is actually a paraphrase of a statement by M. Scholes himself. Real life as a laboratory means that facts must confirm (or cast doubt upon) the predicative ability of theoretical models. Scholes himself did much for the practical use of his ideas, and his theoretical concept rested on the analysis of a huge quantity of facts. Of primary importance was his work as a financial consultant to many institutions.

At the end of the 90's public opinion was stirred by Scholes' activity (as well as that of R. Merton) in the investment fund LTCM (Long-Term Capital Management). This was

[5] Fischer Black, the co-author of this work, died about a year before the Nobel Prize was decided, and since the prize is not awarded posthumously, he did not become a Nobel laureate.

a hedge fund that had been set up in 1994 by John Merriwether, a former security trader at Solomon Brothers. M. Scholes and R. Merton also held managing positions in the fund. The fund was to be oriented primarily on arbitrage deals with extensive use of the latest computer technology and huge databases. Scholes himself described the fund as "a giant vacuum cleaner sucking up nickels that everyone else had overlooked". In its operations the fund made intensive use of financial derivatives (options, futures, swaps, etc.), enabling a huge volume of financial assets to be handled with a small amount of capital. The basic idea in arbitrage deals (in particular in the case of treasury bonds – not only American, but also Japanese, Russian, etc.) was that bonds with the same nominal value, the coupon rate and with the same degree of risk may temporarily have a different price if differences exist in the date of their issue. These price differences balance out over time, but meanwhile a skilful trader can turn a good profit, especially if these deals are made in huge volumes. In order for the company to be able to make deals in a large volume it had to take on an unbearable level of debt[6]. At the beginning the business developed very promisingly and it seemed that the real world really did confirm the practical importance of Scholes' and Merton's theory. However, a crisis occurred in May and June 1998. This was connected with the crisis in Asian capital markets and later also the collapse of the Russian capital market. Investors succumbed to panic and sold Russian and Japanese bonds en masse, below their real value. The derivatives that should have brought huge profits led to a huge loss (roughly USD 4.6 billion). A particular danger lay in the fact that LTCM was not only unable to repay its liabilities towards creditors, but this failure significantly influenced foreign financial markets and threatened a collapse of the international financial system. In the end, the Federal Reserve intervened and the collapse feared was averted.

Public opinion to this day often blames "financial wizards" and hedge funds generally that they introduce instability into the financial system. Can the LTCM crisis really be considered as an evidence that "financial geniuses" (M. Scholes and R. Merton) failed?

The correctness of a theory clearly cannot be judged on the basis of one failure, and indeed one that is the result of particular coincidence of adverse circumstances. Scholes himself emphasised that the real world is not an experimental laboratory, but rather a developing system, where the theory should provide an instrument for minimising risk in such a changing world. In practice the approach of LTCM was to a certain degree an experiment – in particular as regards the high rate of debt. But the shocks that caused its collapse were practically unforeseeable. Neither did the diversification of LTCM's portfolio help, if the risk connected with a variety of assets developed (grew) in the same direction. Real capital markets at the end of the 1990's had not developed (at least over the short term) in accordance with the theory of an efficient capital market.

Crisis processes at the end of the 1990's undoubtedly provided a lesson to financial theoreticians, indeed also for practice and economic policy. This did not mean however a brake on derivatives trading; quite the opposite. Derivative trades grew at a fast rate. New hedge funds have since then been continually set up and the total assets being administered has been growing. Scholes was clearly right in forecasting this development. On the other hand, however, prudence in the policy of these funds has increased and now such high levels of debt are not risked.

Broader perspectives in applying the option pricing model

The term option needs to be understood also in the broader sense as a possibility (but not an obligation) to undertake an activity or project at a future date. In real life a vast number of such situations exists, when the option pricing model may be practically applied. We will draw attention to at least one of them – to the use of this model for evaluating capital expenditure projects. It may for example occur that the net present value of a certain project is negative, but the business is aware of the strategic importance of these investments for the future. If it turns the project down, it will not be possible to build on it in the future, to introduce new production, maintain market position, etc. Or a business is considering whether it should undertake a certain investment now or later. In such situations this concerns real options, the possibility to ensure the right to realise certain projects at a future date, if future conditions develop favourably. The Black – Scholes model may also be used for determining the value of these options[7]. Clearly, we will have to get accustomed to using it as one of the criteria of evaluating also real investment projects.

Most important publications by Myron S. Scholes.

• Black, F. – Scholes, M.S.: The Pricing of Options and Corporate Liabilities. Journal of Political Economy, Vol.81, May-June 1973.
• Scholes, M.S. – Wolfson, M.A.: Taxes and Business Strategies: A Planning Approach . Prentice Hall 1991.
• Black, F. – Jensen, M. – Scholes, M.: The Capital Asset Pricing Model: Some Empirical Tests. In: M. Jensen (ed): Studies in the Theory of Capital Markets. Praeger, Inc. 1972.
• Scholes M.: Derivatives in a Dynamic Environment. Nobel Lecture, December 1997.

[6] At the start of 1998 the fund had own capital of USD 4.72 billion and had borrowed over USD 124.5 billion. Creditors included the largest global banks.

[7] It is important to estimate the time by when the decision on investment must be made (the option's expiration), expected cash flows and their fluctuation. The realisation price is represented by the investment expenditures necessary for realising the project.