РОЗВИТОК ФІНАНСОВО-КРЕДИТНОГО ТА СТРАХОВОГО РИНКУ

УДК 519.86
doi: 10.15330/apred.1.16.40-47

Буртняк І.В.[1], Малицька Г.П.[2]

МОДЕЛЮВАННЯ ЦІНОУТВОРЕННЯ НА ФОНДОВОМУ РИНКУ ЗА ДОПОМОГОЮ МОДЕЛІ CEV

[1]Прикарпатський національний університет
імені В Стефаника,
Міністерство освіти і науки України,
кафедра економічної кібернетики,
вул. Шевченка 57, м. Івано-Франківськ,
76018, Україна,
тел. 0979862632,
e-mail: ivan.burtnyak@pnu.edu.ua

[2]Прикарпатський національний університет
імені В Стефаника,
Міністерство освіти і науки України,
кафедра математичного та функціонального
аналізу,
вул. Шевченка 57, м. Івано-Франківськ,
76018, Україна,
тел.: 0342 59-60-50,
e-mail: hanna.malytska@pnu.edu.ua

Анотація. В даній статті розроблено систематичний метод розрахунку наближених цін широкого спектру цінних паперів, що передбачає використання інструментів спектрального аналізу, теорію сингулярних та регулярних збурень. Ціни деривативів залежать від стохастичної волатильності, яка може бути багатофакторною, в тому сенсі, що на неї може впливати швидкозмінні та повільно змінні фактори.

Удосконалено методику знаходження наближеної ціни для широкого класу деривативів волатильність яких залежить від двох груп змінних чинників, за допомогою спектральної теорії та хвильової теорії сингулярних і регулярних збурень, встановлено аналітичну формулу наближеної ціни активів, які описуються моделлю CEV з стохастичною волатильністю. Здійснено прогнозування цін опціонів, які породжуються дифузійними процесами, де дифузія залежить від двох груп змінних чинників. Розроблено алгоритм обчислення наближеної ціни деривативів і точності оцінок, що дозволяє проводити аналіз та зробити запобіжні висновки і пропозиції, щоб мінімізувати ризики щодо ціноутворення деривативів, які виникають на фондовому ринку. Розроблено методи обчислення наближеної ціни опціонів за допомогою інструментів спектрального аналізу, сингулярної та регулярної хвильової теорії у випадку впливу швидко та повільно діючих чинників. Комбінуючи методи з спектральної теорії сингулярних і регулярних збурень, можна наближено обчислити ціну похідних фінансових інструментів, як розклад за власними функціями. Розроблено алгоритм обчислення наближеної ціни деривативів і точності оцінок, що дозволяє проводити аналіз та зробити запобіжні висновки і пропозиції, щоб мінімізувати ризики щодо ціноутворення деривативів, які виникають на фондовому ринку

Ключові слова ціноутворення деривативів, стохастична волатильність, локальна волатильність, спектральна теорія, теорія сингулярних збурень, теорія регулярних збурень

***Burtnyak I.V.*[1], *Malitska G P.*[2]**

SIMULATION OF STOCK MARKET PRICING USING THE MODEL CEV

[1]Vasyl Stefanyk Precarpatian National University
Ministry of Education and Science of Ukraine,
Department of Economic Cybernetics,
Shevchenko str., 57, Ivano-Frankivsk,
76018, Ukraine,
tel.: 0979862632,
e-mail: ivan.burtnyak@pnu.edu.ua

[2]Vasyl Stefanyk Precarpatian National University
Ministry of Education and Science of Ukraine,
Department of Mathematical and functional analysis,
Shevchenko str., 57, Ivano-Frankivsk,
76018, Ukraine,
tel.: 0342 59-60-50,
e-mail: hanna.malytska@pnu.edu.ua

Abstract. This paper develops a systematic method for calculating approximate prices for a wide range of securities implying the tools of spectral analysis, singular and regular perturbation theory. Price options depend on stochastic volatility, which may be multiscale, in the sense that it may be driven by one fast-varying and one slow-varying factor. Price finding is reduced to the problem solving of eigenvalues and eigenfunctions of a certain equation.

The method of finding the approximate price for a wide class of derivatives whose volatility depends on two groups of variables has been improved, using the spectral theory and wave theory of singular and regular perturbations, Options for forecasting options generated by diffusion processes, where diffusion depends on two groups of variables, have been forecast. An algorithm for calculating the approximate price of derivatives and the accuracy of estimates has been developed, which allows to analyze and draw precautionary conclusions and proposals to minimize the risks of pricing derivatives that arise in the stock market. Methods for calculating the approximate price of options using the tools of spectral analysis, singular and regular wave theory in the case of fast and slow factors are developed. Combining methods from the spectral theory of singular and regular perturbations, it is possible to estimate the price of derivative financial instruments as a schedule by eigenfunctions. An algorithm for calculating the approximate price of derivatives and the accuracy of estimates has been developed, which allows to analyze and draw precautionary conclusions and proposals to minimize the risks of pricing derivatives that arise in the stock market

Keywords: derivative pricing, stochastic volatility, local volatility, spectral theory, singular perturbation theory, regular perturbation theory.

Introduction. Spectral theory was widely used in the second half of the 20th century by many economists. In recent years spectral analysis has become an increasingly popular tool for use in financial mathematics to analyze diffusion models which are based on the expansion of eigenfunctions and eigenvalues of linear operators. For example, it is used to find the price of a European option using Black-Scholes model [8]. Among the scientific problems that can be solved by applying spectral methods: predicting option prices [7] securities interest rates [11], modeling the volatility of financial assets [4].

Assets estimation problems are solved analytically by methods of spectral theory [5]. Spectral theory as well as stochastic volatility models has become an indispensable tool in financial mathematics, for the matter of that, two barrier option prices are subjected to Brownian motion and are correlated with volatility [6]. The study of stochastic volatility, volatility assets in particular, underlies the derivative and is controlled by nonlocal diffusion.

In this article we continue the area of our research [1-2], expending it on the theory model CEV (constant elasticity of variance model), which was designed by John Cox in 1975, employing his methods [3,9-10].

Combining the methods of spectral theory and regular perturbance, we are able to calculate approximately the opportunity cost as expansion of eigenfunctions. We will work with infinitesimal generators of three-dimensional diffusion.

Problem Statement. First, consider the one-dimensional diffusion $dX_t = v(X_t)dt + a(X_t)dW_t$ which has the possibility to show default jump at a speed $h(X_t) \geq 0$, W_t– geometric Brownian motion, X is always strictly positive. We add two nonlocal volatility factors to the total diffusion: $a(X_t) \to a(X_t)f(Y_t, Z_t)$. The first factor Y is dynamic. The second factor Z changes slowly. So, our model is a multidimensional volatile stochastic model.

Let (Ω, F, P) denote probability space that supports correlated Brownian motion $(\mathrm{W}^x, \mathrm{W}^y, W^z)$ and an exponential random variable $\varepsilon \sim Exp(1)$, which is not independent of $(\mathrm{W}^x, \mathrm{W}^y, W^z)$. We assume that the economy with three factors is described by homogeneous time, continuous Markov process $\chi = (\mathrm{X}, \mathrm{Y}, \mathrm{Z})$, which takes values in some state space $\mathrm{E} = I \times \mathrm{R} \times \mathrm{R}$, $I = (e_1, e_2)$, $-\infty \leq e_1 < e_2 \leq \infty$. Suppose that χ begins in E and instantly disappears once $X \notin I$, that is:

The dynamics of χ according to the physical value ℙ , is as follows:

$$\chi_t = \begin{cases} (X_t, Y_t, Z_t), & \tau_I < t \\ \Delta, & \tau_I > t \end{cases}, \quad \tau_I = \inf(t > 0 \colon X_t \notin I),$$

where *(X,Y,Z)* are assigned

$$\begin{cases} dX_t = v(X_t)dt + a(X_t)f(Y_t, Z_t)dW_t^x, \\ dY_t = \frac{1}{\epsilon} a_{11}(Y_t)dt + \frac{1}{\sqrt{\epsilon}} a_{12}(Y_t)dW_t^y, \\ dZ_t = \delta a_{21}(Z_t)dt + \sqrt{\delta} a_{22}(Z_t)dW_t^z, \\ d(W^x, W^y)_t = \rho_{xz}dt, \\ d(W^x, W^z)_t = \rho_{xy}dt, \\ d(W^y, W^z)_t = \rho_{yz}dt, \\ (X_0, Y_0, Z_0) = (x, y, z) \in E. \end{cases}$$

where $(\rho_{xy}, \rho_{xz}, \rho_{yz})$ such as $|\rho_{xy}|, |\rho_{xz}|, |\rho_{yz}| \leq 1$ and $1 + 2\rho_{xy}\rho_{xz}\rho_{yz} - {\rho_{xy}}^2 - {\rho_{xz}}^2 - {\rho_{yz}}^2 \geq 0$, and matrix correlation of Brownian model is positive. The process X can display, for instance, index value, short interest rates, option pricing. The physical value ℙ of the process X, we consider as an instant drift $v(X_t)$ and stochastic volatility $a(X_t)f(Y_t, Z_t) > 0$, which has two components: local $a(X_t)$ and nonlocal $f(Y_t, Z_t)$. Nonlocal volatility component $f(Y_t, Z_t)$ is based on two factors: Y and Z, so for infinitesimal generators have

$$\mathrm{M}_Z^{\epsilon} = \frac{1}{\epsilon}\left(\frac{1}{2} a_{12}^2(y)\partial_{yy}^2 + a_{11}(y)\partial_y\right), \qquad \mathrm{M}_Z^{\delta} = \delta\left(\frac{1}{2} a_{22}^2(z)\partial_{zz}^2 + a_{21}(z)\partial_z\right),$$

Therefore, Y and Z have an internal timeline $\epsilon > 0$ and $\frac{1}{\delta} > 0$. We assume that $\epsilon << 1$ and $\delta << 1$, the internal timeline Y is small, whereas the internal timeline Z is large. So, Y is volatility of fast variable factor, whereas Z is vitality of a slow variable factor. Note that M_Y^{ϵ} and M_Z^{δ}t are

$$L = \frac{1}{2}a^2(x)\partial_{xx}^2 + a_1(x)\partial_x - a_2(x), \; x \in (e_1, e_2), \tag{1}$$

Suppose you have to pay share dividends $S_t = \mathbb{I}_{\{\tau>t\}}X_t,\; S > 0.$ then the state space X will be $e_1, e_2 = (0, \infty)$. Consider a multidimensional diffusion process at Killing (default jumps) of constant variable model. In particular, $\widetilde{\mathbb{P}}$ dynamics of X default is set as

$$dX_t = \left(\mu + cX_t^{2\eta}\right)X_t dt + f(Y_t, Z_t)X_t^{\eta+1}d\widetilde{W}_t^x, \qquad h(X_t) = \mu + cX_t^{2\eta}.$$

To simplify calculations assume that the risk-free interest rates $r = 0$, $\mu > 0$, $c > 0$, Y and Z are fast and slow variables of volatility, which are defined

$$\begin{cases} dX_t = \left(a_1(X_t) - a(X_t)f(Y_t,Z_t)\Omega(Y_t,Z_t)\right)dt + a(X_t)f(Y_t,Z_t)d\widetilde{W}_t^x, \\ dY_t = \left(\frac{1}{\epsilon}a_{11}(Y_t) - \frac{1}{\sqrt{\epsilon}}a_{12}(Y_t)\Lambda(Y_t,Z_t)\right)dt + \frac{1}{\sqrt{\epsilon}}a_{12}(Y_t)d\widetilde{W}_t^y, \\ dZ_t = \left(\delta a_{21}(Z_t) - \sqrt{\delta}a_{22}(Z_t)\Gamma(Y_t,Z_t)\right)dt + \sqrt{\delta}a_{22}(Z_t)d\widetilde{W}_t^z, \\ d\langle\widetilde{W}^x, \widetilde{W}^y\rangle_t = \rho_{xy}dt, \\ d\langle\widetilde{W}^x, \widetilde{W}^z\rangle_t = \rho_{xz}dt, \\ d\langle\widetilde{W}^y, \widetilde{W}^z\rangle_t = \rho_{yz}dt, \\ (X_0, Y_0, Z_0) = (x, y, z) \in E, \end{cases}$$

where

$$d\widetilde{W}_t^x := dW_t^x + \left(\frac{v(X_t) - b(X_t)}{a(X_t)f(Y_t,Z_t)} + \Omega(Y_t,Z_t)\right)dt,$$
$$d\widetilde{W}_t^y := dW_t^y + \Lambda(Y_t,Z_t)dt,$$
$$d\widetilde{W}_t^z := dW_t^z + \Gamma(Y_t,Z_t)dt,$$

In our study, there may be two possible ways of default when X is beyond the time-frame I, or at random time τ_h, ($h(X_t) \geq 0$ stochastic value (the so-called level of danger). Mathematically default time τ can be expressed as follows [2].

Volatility X includes the local component X_t^{η} and nonlocal component of multidimensionality $f(Y_t, Z_t)$. We assume, η <0, that is local volatility component X_t^{η} increases when X_t, decreases. It means that prices and volatility have negative correlation. Stochastic danger level $h(X_t)$ increases when X decreases. Now let's calculate the approximate price of European option for assets S. The European option price can be defined by the formula (2).

$$\langle \mathrm{M}_2 \rangle = \frac{1}{2}\bar{\sigma}^2 x^{2\eta+2}\partial_{xx}^2 + (\mu + cx^{2\eta})x\partial_x - (\mu + cx^{2\eta}), \tag{2}$$

M_2– infinitesimal generator, the end of the time-frame that is the point $e_2 = \infty$ is a natural border. However, the classification of point $e_1 = 0$ depends on the value η and $c/\bar{\sigma}^2$. Therefore, we present the following classification:

1) $c/\bar{\sigma}^2 \geq 1/2, \quad \eta < 0,\; e_1 = 0$ – trivial case,

2) $c/\bar{\sigma}^2 \in (0,1/2)$, $\eta \in \left[\frac{c}{\bar{\sigma}^2} - 1/2, 0\right)$, $e_1 = 0$ – this number serves as the initial moment,

3) $c/\bar{\sigma}^2 \in (0,1/2)$, $\eta < \frac{c}{\bar{\sigma}^2} - \frac{1}{2}$, $e_1 = 0$ under such circumstances the start of time-frame is stable.

If parameters $(c, \bar{\sigma}, \eta)$ are satisfying $c/\bar{\sigma}^2 \in (0,1/2)$, and $\eta \in \left[\frac{c}{\bar{\sigma}^2} - \frac{1}{2}, 0\right)$, $e_1 = 0$, then e_1 is considered as Killing border. To calculate the approximate price of the European option, we must find eigenfunctions $\{\psi_n\}$, eigenvalues $\{\lambda_n\}$ operator $\langle \mathrm{M}_2 \rangle$. Note that $\langle \mathrm{M}_2 \rangle$, presented in (2), looks like infinitesimal generator of the one-dimensional diffusion (1) with volatility $\bar{\sigma}a(x)$, deviation $\left(a_1(x) - \overline{f\Omega}a(x)\right)$ and Killing $a_2(x)$, $dom(\langle \mathrm{M}_2 \rangle)$ includes marginal conditions which are to be imposed at the end e_1 and e_2 equation $-\langle \mathrm{M}_2 \rangle \psi_n = \lambda_n \psi_n$, $\psi_n \in dom(\langle \mathrm{M}_2 \rangle)$, at the interval $(0, \infty)$ with $\langle \mathrm{M}_2 \rangle$ is defined as (5) follows

$$\lim_{x \to 0} \psi_n = 0, \text{ if } \quad \frac{c}{\bar{\sigma}^2} \in \left(0, \frac{1}{2}\right).$$

Results.

The results of this research result from the article [2]

$$\psi_n = A^{\frac{\upsilon}{2}} \sqrt{\frac{(n-1)!\,\mu}{\Gamma(\upsilon + n)}}\, x\, exp(-Ax^{-2\eta}) L_{n-1}^{(\upsilon)}(Ax^{-2\eta}), \quad n = 1,2,3, \dots,$$

$$A = \frac{\mu}{\bar{\sigma}^2 |\eta|}, \quad \lambda_n = 2\mu|\eta|(n + \upsilon), \quad \upsilon = \frac{1 + 2(\frac{2}{\bar{\sigma}^2})}{2|\eta|},$$

where $L_n^{(\upsilon)} = \sum_{i=0}^{n} (-1)^i \binom{n+\upsilon}{n-i} \frac{x^i}{i!}$ is the generalized Laguerre polynomials. Write expressions for the operators $\mathcal{A}$ and $\mathcal{B}$:

$$\mathcal{A} = -\nu_3 x^{\eta+1} \partial_x x^{2\eta+2} \partial_{xx}^2 - \nu_2 x^{2\eta+2} \partial_{xx}^2, \qquad \mathcal{B} = -\nu_1 x^{\eta+1} \partial_x - \nu_0.$$

Analytical expressions for $\mathcal{A}_{k,n}, \mathcal{B}_{k,n}$ and $\widetilde{\mathcal{B}}_{k,n}$ can be obtained by making a change of variables [1] $Ax^{-2\eta} \to y$, using $\partial_y L_n^{\upsilon}(y) = -L_{n-1}^{(\upsilon+1)}(y)$ and $\int_0^\infty y^\alpha e^{-y} L_n^{(\alpha)}(y) L_m^{(\alpha)}(y) dy = \frac{\Gamma(n+\alpha+1)}{n!} \delta_{nm}$

where δ_{nm} Kronecker symbol. Formulas for determining $\mathcal{A}_{k,n}, \mathcal{B}_{k,n}$ і $\widetilde{\mathcal{B}}_{k,n}$, have the following form Cox (1975)

$$c_n = (\psi_n, 1) = \frac{2}{\bar{\sigma}} \sqrt{\frac{\pi}{\kappa}} \mathcal{N}_n A^n e^{-A^2/4}.$$

The European option profit with strike price $K > 0$ can be decomposed as follows [9]:

$$(K - S_t)^+ = (K - X_t)^+ \mathbb{I}_{\{\tau > t\}} + K\left(1 - \mathbb{I}_{\{\tau > t\}}\right). \tag{3}$$

The first item on the right hand side (3) profit option is submitted to default at time t. The second item is profit option which is submitted after the default, which occurs at time t. So, the value of the option with strike price K – is denoted as $u^{\epsilon,\delta}(t, x; K)$ and can be expressed as the sum of:

$$u^{\epsilon,\delta}(t,x;K) = u_o^{\epsilon,\delta}(t,x;K) + u_D^{\epsilon,\delta}(t,x;K),$$

where

$$u_o^{\epsilon,\delta}(t,x;K) = \widetilde{\mathbb{E}}_{x,y,z}\left[(K - X_t)^+ \mathbb{I}_{\{\tau>t\}}\right],$$

$$u_D^{\epsilon,\delta}(t,x;K), = K - K\widetilde{\mathbb{E}}_{x,y,z}\left[\mathbb{I}_{\{\tau>t\}}\right] = K - K\int_0^\infty \widetilde{\mathbb{E}}_{x,y,z}\left[\delta_{x'}(X_t)\mathbb{I}_{\{\tau>t\}}\right]d\,x'$$

$$= K - K\int_0^\infty u_1^{\epsilon,\delta}(t,x;x')dx',$$

$$u_1^{\epsilon,\delta}(t,x;x') = \widetilde{\mathbb{E}}_{x,y,z}\left[\delta_{x'}(X_t)\mathbb{I}_{\{\tau>t\}}\right],\ 1 \notin L^2(\mathbb{R}^+,\mathfrak{m})\cdot$$

We used that $1 = \int_0^\infty \delta_{x'}(X_t)d\,x'$ on the set $\{\tau > T\}$.

So, as the functions of profit $H_0(x) = (K - x)^+$and $H_1(x) = \delta_{x'}(x)$ are $L^2(\mathbb{R}^+,\mathfrak{m})$, we can calculate:

$$c_{0,n} = (\psi_n(\cdot),(k-\cdot)^+),\quad c_{1,n} = (\psi_n,\delta_{x'}).$$

Expressions for $c_{0,n}$ and $c_{1,n}$can be found in [10].

The estimated value of the European option can now be calculated using the theorems 1, 2 and 3, [2].

For the European variant the option volatility $I^{\epsilon,\delta}$ with price $u^{\epsilon,\delta}(t,x;K)$ is determined by using

$$u^{\epsilon,\delta}(t,x;K) = u^{BS}\left(t,x,I^{\epsilon,\delta};K\right)$$

where $u^{BS}\left(t,x,I^{\epsilon,\delta};K\right)$ Black-Scholes price with volatility $I^{\epsilon,\delta}$.

The calculation results are presented in Figure 1

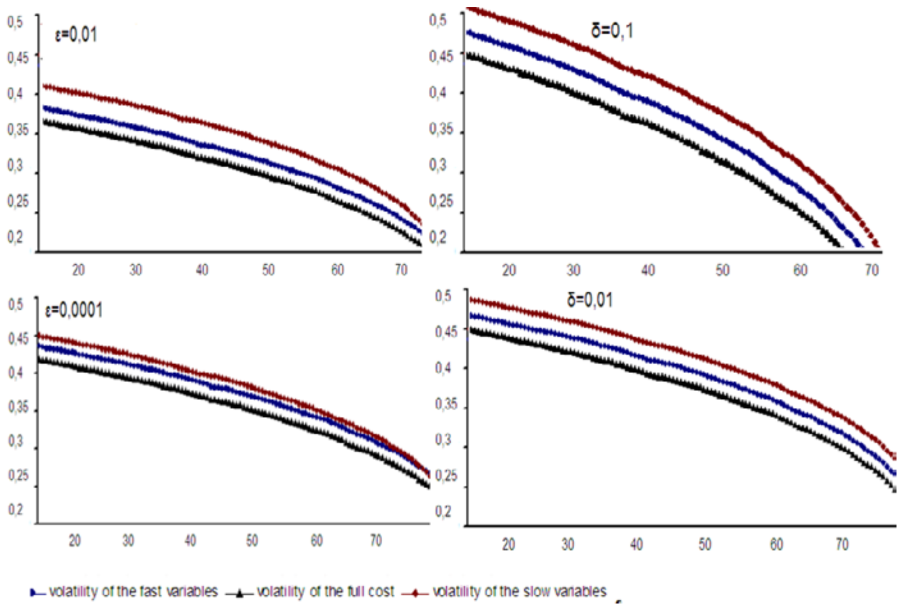

Fig.1. Volatility Dynamics

Volatility is constructed on the left hand side of Figure 1 depends on the price, the option for the model, which has only volatility of the fast variables. Dynamics Y and volatility function f are defined by the formula.

$$dY_t = \left(-\frac{1}{\epsilon}Y_t - \frac{1}{\sqrt{\epsilon}}a_{12}\mathrm{Er}f(Y_t)\right)dt + a_{12}d\widetilde{W}_t^y, \quad f(Y_t) = \frac{\sigma\exp(Y_t)}{\exp\left(-\frac{a_{12}^2}{2}\right)},$$

$$\mathrm{Erf}(y) := \frac{2}{\sqrt{\pi}}\int_0^y e^{-t^2}dt.$$

Volatility was built for comparison of full value u^ϵ and on the right hand side of Figure 1 is shown volatility caused by approximate price, the option for the model with volatility of the slow variables. Dynamics Z and volatility function f are set

$$dZ_t = \left(-\delta Z_t - \sqrt{\delta}a_{22}\mathrm{Erf}(Z_t)\right)dt + a_{22}d\widetilde{W}_t^z, \quad f(Z_t) = \frac{\sigma\exp(Z_t)}{\exp(z)}.$$

As expected, ε and δ which move to the zero, volatility moves to volatility price implied by full value.

Conclusions. This paper extends the method of finding approximate price for a wide range of derivative assets. One of the main advantages of our pricing methodology is that by combining methods of the spectral theory of singular and regular perturbance, the calculation of asset prices leads to solving the equation by eigenvalues and eigenfuntion methods as well as by solving Poisson equation. Once this equation is solved, the approximate price of a derivative asset may be calculated formulaically. The used method of pricing of European options on the basis of research of behavior of volatility and the analysis of profitability of financial instruments allows to increase accuracy of the forecast and to make the reasonable administrative strategic decisions by participants of the stock market.

1. Burtnyak, I.V., and A.P. Malytska. "The Investigation of Securities Cost Using Methods of Spectral Analysis." *International Journal of Economic Research*, vol. 14, issue 15, 2017, pp. 705–715.
2. Burtnyak I.V., Malytska A.P. Spectral study of options based on CEV model with multidimensional volatility. *Investment Management and Financial Innovations.* 15(1). 2018. Pp.18-25. doi:10.21511/imfi.15(1).2018.03].
3. Cox J.. Notes on Option Pricing I: Constant Elasticity of Diffusions, Unpublished draft. Stanford University, 1975.
4. Davydov D, Linetsky V. Structuring, Pricing and Hedging Double-barrier Step Options. *Journal of Computational Finance*. №.5. 2001. Pp. 55–88.
5. Fouque J-P., Papanicolaou G., Sircar R. Derivatives in Financial Markets with Stochastic Volatility. Cambridge University Press, 2000.
6. Gatheral J. The Volatility Surface: a Practitioner's Guide. John Wiley and Sons, Inc, 2006.
7. Goldstein R.S., Keirstead W.P. On the Term Structure of Interest Rates in the Presence of Reflecting and Absorbing Boundaries, SSRN eLibrary, 1997, pp. 381–395.
8. Lewis A. Applications of Eigenfunction Expansions in Continuous-time Finance. *Mathematical Finance*. №.8. 1997. Pp. 349–383.
9. Linetsky V. Lookback Options and Diffusion Hitting Times: A Spectral Expansion Approach. *Finance and Stochastics*. №.8(3). 2004. Pp. 373–398.
10. Lorig M. Pricing Derivatives on Multiscale Diffusions: An Eigenfunction Expansion Approach. Princeton University - Department of Operations Research & Financial Engineering (ORFE), 2012.
11. Pelsser A. Pricing Double Barrier Options Using Laplace Transforms. *Finance and Stochastics*. №4. 2000. Pp. 95–104.

References

12. Burtnyak, I.V., and A.P. Malytska. "The Investigation of Securities Cost Using Methods of Spectral Analysis." *International Journal of Economic Research*, vol. 14, issue 15, 2017, pp. 705–715.
13. Burtnyak, I.V., and A.P. Malytska. "Spectral study of options based on CEV model with multidimensional volatility." *Investment Management and Financial Innovations*, 15(1), 2018, pp.18-25. doi:10.21511/imfi.15(1).2018.03].
14. Cox, J. *Notes on Option Pricing I: Constant Elasticity of Diffusions, Unpublished draft.* Stanford University, 1975.

15. Davydov, D, and V. Linetsky. "Structuring, Pricing and Hedging Double-barrier Step Options." *Journal of Computational Finance*, no.5, 2001, pp. 55–88.
16. Fouque, J-P., Papanicolaou, G., and R. Sircar. *Derivatives in Financial Markets with Stochastic Volatility*. Cambridge University Press, 2000.
17. Gatheral, J. *The Volatility Surface: a Practitioner's Guide.* John Wiley and Sons, Inc, 2006.
18. Goldstein, R.S., and W.P.Keirstead. *On the Term Structure of Interest Rates in the Presence of Reflecting and Absorbing Boundaries,* SSRN eLibrary, 1997, pp. 381–395.
19. Lewis, A. "Applications of Eigenfunction Expansions in Continuous-time Finance." *Mathematical Finance*, no.8, 1997, pp. 349–383.
20. Linetsky, V. "Lookback Options and Diffusion Hitting Times: A Spectral Expansion Approach." *Finance and Stochastics,* no.8(3), 2004 , pp. 373–398.
21. Lorig, M. *Pricing Derivatives on Multiscale Diffusions: An Eigenfunction Expansion Approach.* Princeton University - Department of Operations Research & Financial Engineering (ORFE), 2012.
22. Pelsser, A. "Pricing Double Barrier Options Using Laplace Transforms." *Finance and Stochastics*, no.4, 2000, pp. 95–104.

УДК 336.77
doi: 10.15330/apred.1.16.47-58

Варцаба В.І.[1], Чубарь О.Г.[2], Огородник В.О.[3]

ФІНАНСОВА ПІДТРИМКА БІЗНЕСУ: БАНКІВСЬКИЙ СЕКТОР VS «КОРОНАВІРУСНА» КРИЗА

Ужгородський національний університет,
Міністерство освіти і науки України,
кафедра фінансів і банківської справи,
вул. Університетська, 14, кім. 405,
м. Ужгород, 88017, Україна
[1] тел. 0505026505
e-mail: vira.vartsaba@uzhnu.edu.ua
[2] тел. 0506098692
e-mail: oksana.chubar@uzhnu.edu.ua
[3] тел. 0509509640
e-mail: valeriya.ohorodnyk@uzhnu.edu.ua

Анотація. Негативні наслідки, породжені обмежувальними заходами щодо запобігання виникненню і поширенню гострої респіраторної хвороби COVID-19, спричиненої коронавірусом SARS-CoV-2, призвели до відчутного зниження ділової активності по всьому світу та виявили неготовність владних кіл до швидкого розв'язання питань такого масштабу. Метою даної публікації є дослідження можливостей надання фінансово-кредитної підтримки бізнесу за умов протидії «коронавірусній» кризі, що охопила весь світ і не оминула Україну.

У статті проаналізовано обсяги фінансових результатів бізнес-структур у 2020 році та встановлено, що збитки перевищили відповідні показники минулого року більш ніж втричі, а обсяг одержаних прибутків на 10% менший минулорічного показника. Також виявлено, що «коронавірусна» криза суттєво вплинула на економічні настрої українців, що проявилося у зниженні кожного компоненту індикатора економічних настроїв та індикатора споживчої впевненості.

Хоча органами державної влади запроваджуються певні антикризові заходи, авторами даного дослідження встановлено, що задекларовані форми державного стимулювання суб'єктів підприємництва та обсяги фінансово-кредитної підтримки не в змозі суттєво вплинути на стабілізацію ситуації, а можуть лише пом'якшити та згладити негативні тенденції.

У статті висвітлено окремі тенденції та особливості реалізації Програми «Доступні кредити 5-7-9%», за результатами чого зроблено висновок про антикризовий, а не