КИЇВСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ
ІМЕНІ ТАРАСА ШЕВЧЕНКА

БЕРДЯНСЬКИЙ ДЕРЖАВНИЙ ПЕДАГОГІЧНИЙ УНІВЕРСИТЕТ

ДУ «ІНСТИТУТ ЕКОНОМІКИ І ПРОГНОЗУВАННЯ НАН УКРАЇНИ»

КИЇВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
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ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ

ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ

ЗАПОРІЗЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ

ВІЛЬНЮСЬКИЙ УНІВЕРСИТЕТ (ЛИТВА)

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Рекомендовано вченою радою економічного факультету Київського національного університету імені Тараса Шевченка
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У монографії розглядаються прикладні аспекти прогнозування розвитку соціально-економічних систем. Обгрунтовуються математичні методи мікроекономічного та макроекономічного прогнозування, здійснено оцінювання ефективності інвестицій в економіку України у 2012-2017 роках з позицій теорії еволюційних процесів, проведено математичне моделювання динаміки росту населення Землі, моделювання впливу показників σ–конвергенції на динаміку макропоказників. Розроблено систему прогнозування впливу інфляції на економічну поведінку домогосподарств України, запропоновано сучасні методи в дослідженні безпеки економічних систем, розроблено комплекс моделей для прогнозування розподілу та використання бюджетних коштів на програми розвитку Збройних Сил України в умовах економічної нестабільності, тощо. Окремо увагу приділено питанням економічного прогнозування та управління курортними рекреаціями і туризмом в регіонах України та застосуванню методів «зеленої» економіки. Для фахівців в області моделювання, прогнозування, та управління складними соціально-економічними системами, а також викладачів, аспірантів і студентів економічних спеціальностей.

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стохастичних рівнянь. Представлення завдання прогнозування стану складною системи в інноваційної економіці на основі інтегральної моделі у фазовому просторі з рівняннями спостережень, розробка фільтрів і алгоритмів оптимального управління. Перспективою подальших досліджень є проведення комп’ютерних експериментів.

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1.18. Quantum econophysics of cryptocurrencies crises

1 Introduction

The attempts to create an adequate model of socio-economic critical events, which, as it has been historically proven, are almost permanent, were, are and will always be made. Actually, it is a super task, impossible to solve. However, the potentially useful solutions, local in time or other socio-economic logistic coordinates, are possible. In fact, they have to be the object of interest for a real and effective economic science.

Econophysics is a young interdisciplinary scientific field, which developed and acquired its name at the end of the last century [1]. Quantum econophysics, a direction distinguished by the use of mathematical apparatus of quantum mechanics as well as its fundamental conceptual ideas and relativistic aspects, developed within its boundaries just a couple of years later, in the first decade of the 21-st century [2-4].

According to classical physics, immediate values of physical quantities, which describe the system status, not only exist, but can also be exactly measured. Although non-relativistic quantum mechanics doesn't reject the existence of immediate values of classic physical quantities, it postulates that not all of them can be measured simultaneously (Heisenberg uncertainty ratio). Relativistic quantum mechanics denies the existence of immediate values for all kinds of physical quantities, and, therefore, the notion of system status seizes to be algoristic.

In this paper, we will demonstrate the possibilities of quantum econophysics on the example of the application of the Heisenberg uncertainty principle and the random matrices theory to the actual and debatable now the market of cryptocurrencies.

2 Heisenberg uncertainty principle and economic analogues of basic physical quantities

In paper [4] we have suggested a new paradigm of complex systems modelling based on the ideas of quantum as well as relativistic mechanics. It has been revealed that the use of quantum-mechanical analogies (such as the uncertainty principle, notion of the operator, and quantum measurement interpretation) can be applied to describing socio-economic processes. Methodological and philosophical analysis of fundamental physical notions and constants, such as time, space and spatial coordinates, mass, Planck's constant, light velocity from the point of view of modern theoretical physics provides an opportunity to search of adequate and useful analogues in socio-economic phenomena and processes.

The Heisenberg uncertainty principle is one of the cornerstones of quantum mechanics. The modern version of the uncertainty principle, deals not with the precision of a measurement and the disturbance it introduces, but with the intrinsic uncertainty any quantum state must possess, regardless of what measurement is performed [5, 6]. Recently, the study of uncertainty relations in general has been a topic of growing interest, specifically in the setting of quantum information and quantum cryptography, where it is fundamental to the security of certain protocols [7-9].

Time, distance and mass are normally considered to be initial, main or basic physical notions, that are not strictly defined. It is thought that they can be matched with certain numerical values. In this case other physical values, e.g. speed, acceleration, pulse, force, energy, electrical charge, current etc. can be conveyed and defined with the help of the three above-listed ones via appropriate physical laws.

Let us emphasize that none of the modern physical theories, including relativistic and quantum physics, can exist without basic notions. Nevertheless, we would like to draw attention to the following aspects. As Einstein has shown in his relativity theory, presence of heterogeneous masses leads to the distortion of 4-dimensional time-space in which our world exists. As a result Cartesian coordinates of the 4-dimensional Minkowski space (x, y, z, ict), including three ordinary Cartesian coordinates (x, y, z) and the forth formally introduced time-coordinate ict ($i = \sqrt{-1}$ - imaginary unit, c - speed of light in vacuum, t - time), become curvilinear [10].

It is also possible to approach the interpretation of Einstein's theory from other point of view, considering that the observed heterogeneous mass distribution is the consequence of really existing curvilinear coordinates (x, y, z, ict). Then the existence of masses in our world becomes the consequence of geometrical factors (presence of time-space and its curvature) and can be described in geometrical terms.

If we step away from global macro-phenomena that are described by the general relativity theory, and move to micro-world, where laws of quantum physics operate, we come to the same conclusion about the priority of time-space coordinates in the definition of all other physical values, mass included.

To demonstrate it, let us use the known Heisenberg's uncertainty ratio which is the fundamental consequence of non-relativistic quantum mechanics axioms and appears to be (e.g. [4]):

$$\Delta x \cdot \Delta v \geq \frac{\hbar}{2m_0}, \quad (1)$$

where Δx and Δv are mean square deviations of x coordinate and velocity v corresponding to the particle with (rest) mass m_0, $\hbar$ - Planck's constant. Considering values Δx и Δv to be measurable when their product reaches its minimum, we derive (from (1)):

$$m_0 = \frac{\hbar}{2 \cdot \Delta x \cdot \Delta v}, \quad (2)$$

i.e. mass of the particle is conveyed via uncertainties of its coordinate and velocity – time derivative of the same coordinate.

According to the concept [11, 12], space, time, and four fundamental physical interactions (gravitational, electromagnetic, strong and weak) are secondary notions. They share common origins and are generated by the so-called world matrix which has special structure and peculiar symmetrical properties. Its elements are complex numbers which have double transitions in some abstract pre-space.

At the same time, physical properties of space-time in this very point are defined by the nonlocal ("immediate") interaction of this point with its close and distant neighborhood, and acquire statistical nature. In other words, the observed space coordinates and time have statistical nature.

In our opinion the afore-mentioned conception of nonlocal statistical origin of time and space coordinates can be qualitatively illustrated on the assumptions of quantum-mechanical uncertainty principle using known ratios (e.g. [4])

$$\Delta p \cdot \Delta x \sim \hbar,\ \Delta E \cdot \Delta t \sim \hbar;\ \Delta p \cdot \Delta t \sim \frac{\hbar}{c}. \quad (4)$$

Interpreting values $\Delta E, \Delta p, \Delta x, \Delta t$ as uncertainties of particle's energy E, its pulse p, coordinate x and time localization t, let us conduct the following reasoning.

While $\Delta x \to 0$ uncertainty of pulse, and thus particle energy, uncertainty, formally becomes as big as possible, which can be provided only by its significant and nonlocal energetical interaction with the rest of the neighborhood. On the other side, while $\Delta p \to 0$ the particle gets smeared along the whole space, i.e. becomes delocalized. It might be supposed that the fact of "delocalized" state of the particle takes place in any other, not necessarily marginal Δx and Δp value ratios.

Speaking of economic laws, based on the results of both physical (e.g. quantities of material resources) and economical (e.g. their value) dynamic measurements, the situation will appear to be somewhat different. Adequacy of the formalisms used for mathematical descriptions has to be constantly checked and corrected if necessary. The reason is that measurements always imply a comparison with something, considered to be a model, while there are no constant standards in economics (they change not only quantitavely, but also qualitatively – new standards and models appear). Thus, economic measurements are fundamentally relative, are local in time, space and other socio-economic coordinates, and can be carried out via consequent and/or parallel comparisons “here and now”, “here and there”, “yesterday and today”, “a year ago and now” etc. (see [4, 13] for further information on the subject).

Due to these reasons constant monitoring, analysis, and time series prediction (time series imply data derived from the dynamics of stock indices, exchange rates, cryptocurrencies prices, spot prices and other socio-economic indicators) becomes relevant for evaluation of the state, tendencies, and perspectives of global, regional, and national economies.

Let us proceed to the description of structural elements of our work and building of the model. Suppose there is a set of K time series, each of N samples, that correspond to the single distance T, with an equal minimal time step $\Delta t_{\min}$:

$$X_i(t_n),\ \ t_n = \Delta t_{\min} n;\ \ n = 0,1,2,...N-1;\ \ i = 1,2,...K\,. \tag{5}$$

To bring all series to the unified and non-dimentional representation, accurate to the additive constant, we normalize them, having taken a natural logarithm of each term of the series:

$$x_i(t_n) = \ln X_i(t_n),\ \ t_n = \Delta t_{\min} n;\ \ n = 0,1,2,...N-1;\ \ i = 1,2,...K\,. \tag{6}$$

Let us consider that every new series $x_i(t_n)$ is a one-dimensional trajectory of a certain fictitious or abstract particle numbered i, while its coordinate is registered after every time span $\Delta t_{\min}$, and evaluate mean square deviations of its coordinate and speed in some time window ΔT:

$$\Delta T = \Delta N \cdot \Delta t_{\min} = \Delta N,\ \ 1 << \Delta N << N\,. \tag{7}$$

The «immediate» speed of i particle at the moment t_n is defined by the ratio:

$$v_i(t_n) = \frac{x_i(t_{n+1}) - x_i(t_n)}{\Delta t_{\min}} = \frac{1}{\Delta t_{\min}} \ln \frac{X_i(t_{n+1})}{X_i(t_n)} \tag{8}$$

with variance D_{v_i} and mean square deviation Δv_i.

To evaluate dispersion D_{x_i} coordinates of the i particle are used in an approximated ratio:

$$2D_{x_i} \approx D_{\Delta x_i}\,, \tag{9}$$

where

$$D_{\Delta x_i} = \ < \left(x_i(t_{n+1}) - x_i(t_n)\right)^2 >_{n,\Delta N} - \left(< x_i(t_{n+1}) - x_i(t_n) >_{n,\Delta N}\right)^2 =$$

$$= \ < \ln^2 \frac{X_i(t_{n+1})}{X_i(t_n)} >_{n,\Delta N} - \left(< \ln \frac{X_i(t_{n+1})}{X_i(t_n)} >_{n,\Delta N} \right)^2, \tag{10}$$

which is derived from the supposition that x coordinates neighboring subject to the time of deviation from the average value $\bar{x}$ are weakly correlated:

$$<\left(x_i(t_n)-\bar{x}\right)\left(x_{i+1}(t_n)-\bar{x}\right)>_{n,\Delta N}\approx 0\,. \qquad (11)$$

Thus we get:

$$\Delta x_i=\sqrt{\frac{D_{\Delta x_i}}{2}}=\frac{1}{\sqrt{2}}\left(<\ln^2\frac{X_i(t_{n+1})}{X_i(t_n)}>_{n,\Delta N}-\left(<\ln\frac{X_i(t_{n+1})}{X_i(t_n)}>_{n,\Delta N}\right)^2\right)^{\frac{1}{2}}. \qquad (12)$$

It is also worth noting that the value

$$\left|v_i(t_n)\right|\cdot\Delta t_{\min}=\left|\ln\frac{X_i(t_{n+1})}{X_i(t_n)}\right|,$$

which, accurate to multiplier $\Delta t_{\min}$ coincides with $\left|v_i(t_n)\right|$, is commonly named absolute returns, while dispersion of a random value $\ln\left(X_i(t_{n+1})/X_i(t_n)\right)$, which differs from D_{v_i} by $(\Delta t_{\min})^2$ – volatility [14].

The chaotic nature of real time series allows to $x_i(t_n)$ as the trajectory of a certain abstract quantum particle (observed at $\Delta t_{\min}$ time spans). Analogous to (1) we can write an uncertainty ratio for this trajectory:

$$\Delta x_i\cdot\Delta v_i\sim\frac{h}{m_i}, \qquad (13)$$

or:

$$\frac{1}{\Delta t_{\min}}\left(<\ln^2\frac{X_i(t_{n+1})}{X_i(t_n)}>_{n,\Delta N}-\left(<\ln\frac{X_i(t_{n+1})}{X_i(t_n)}>_{n,\Delta N}\right)^2\right)\sim\frac{h}{m_i}, \qquad (14)$$

where m_i - economic "mass" of an i series, h - value which comes as an economic Planck's constant.

Having rewritten the ration (13):

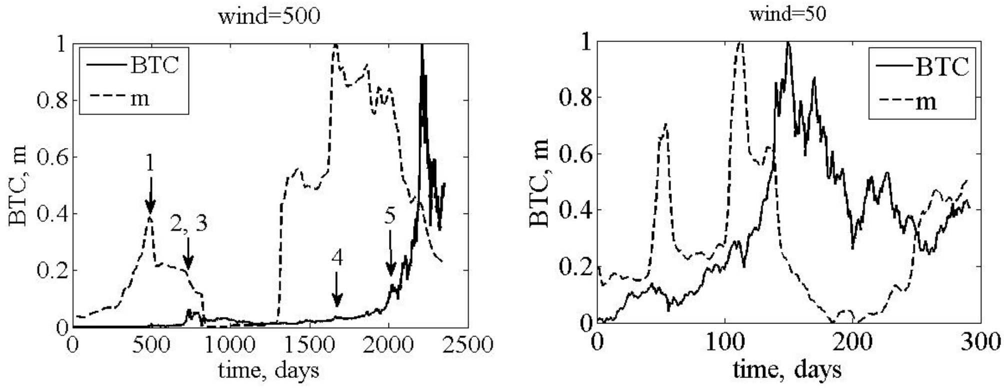
$$\Delta t_{\min}\cdot\frac{m_i}{(\Delta t_{\min})^2}\left(<\ln^2\frac{X_i(t_{n+1})}{X_i(t_n)}>_{n,\Delta N}-\left(<\ln\frac{X_i(t_{n+1})}{X_i(t_n)}>_{n,\Delta N}\right)^2\right)\sim h \qquad (15)$$

and interpreting the multiplier by $\Delta t_{\min}$ in the left part as the uncertainty of an "economical" energy (accurate to the constant multiplier), we get an economic analog of the ratio $\Delta E\cdot\Delta t\sim\hbar$.

Since the analogy with physical particle trajectory is merely formal, h value, unlike the physical Planck's constant $\hbar$, can, generally speaking, depend on the historical period of time, for which the series are taken, and the length of the averaging interval (e.g. economical processes are different in the time of crisis and recession), on the series number i etc. Whether this analogy is correct or not depends on particular series' properties.

In recent work [14], we tested the economic mass as an indicator of crisis phenomena on stock index data. In this work we will test the model for the cryptocurrency market on the example of the bitcoin [15]. Bitcoin is an important electronic and decentralized cryptographic currency system. It is based on a peer-to-peer network architecture and secured by cryptographic protocols and there is no need for a central authority or central bank to control the money supply within the system. Bitcoin attracts considerable attention of researchers of different levels, using modern methods and models of analysis of the peculiarities of the dynamics of the popular digital currency. Thus, the identification of possible trends of the cryptocurrency movement, construction and modeling of indicators of stability and possible crisis states is extremely relevant.

During the entire period (16.07.2010 - 01.04.2018) of verifiably fixed daily values of the bitcoin price (BTC) (https://finance.yahoo.com/cryptocurrencies) in relative units, five crisis phenomena were recorded and marked with arrows on fig. 1. In order to study the possibility of constructing indicators of crisis phenomena in the market of cryptocurrency, the price range of bitcoin was divided into five parts in accordance with the periodization of crises [16]: 1). From 19.02.2013 to 31.05.2013. 2). From 10.10.2013 to 31.12.2013. 3). From 18.12.2013 to 02.03.2014. 4). From 22.04.2017 to 31.07.2017. 5). From 15.07.2017 to 02.10.2018.



a) b)

Fig. 1. The comparative dynamics of the price of the bitcoin and the economic mass for a) the full time series of the bitcoin (16.07.2010 - 01.05.2018) and b) the time series containing the latest winter crisis in 2018 (01.09.2017 – 01.05.2018).

Calculations were carried out within the framework of the algorithm of a moving window. For this purpose, the part of the time series (window), for which there were measures economic mass m was selected, then the window was displaced along the time series in a one-day increment and the procedure repeated until all the studied series had exhausted. Further, comparing the dynamics of the actual time series and the corresponding measures m, we can judge the characteristic changes in the dynamics of the behavior of m with changes in the cryptocurrency.

Obviously, there is a dynamic characteristic values m depending on the internal dynamics of the market. In times of crisis known (marked by arrows in the fig. 1a) mass m is significantly reduced in the pre-crisis period. In fig. 1b mass calculations were proved only for the last fifth crisis and with the window not in 500 days, but only 50.

Obviously that the value of m remains a good indicator-precursor and in this case.

The following method of quantum econophysics is borrowed from nuclear physicists and is called random matrix theory (RMT)

3 Random matrix theory and financial crises

The study of statistical properties of matrices with independent random elements — random matrices — has a rich history originating in nuclear physics [16-18]. In nuclear physics, the problem of interest 50 years ago was to understand the energy levels of complex nuclei, which the existing models failed to explain. Random matrix theory developed in this context by Wigner, Dyson, Mehta, and others in order to explain the statistics of energy levels of complex quantum systems. They postulated that the Hamiltonian describing a heavy nucleus can be described by a matrix H with independent random elements H_{ij} drawn from a probability distribution. Based on this assumption, a series of remarkable predictions were made that are found to be in agreement with the experimental data. For complex quantum systems, RMT predictions represent an average over all possible interactions. Deviations from the universal predictions of RMT identify system specific, nonrandom properties of the system under consideration, providing clues about the underlying interactions.

Unlike most physical systems, where one relates correlations between subunits to basic interactions, the underlying ‘‘interactions’’ for the stock market problem are not known. Here, we analyze cross correlations between stocks by applying concepts and methods of random matrix theory, developed in the context of complex quantum systems where the precise nature of the interactions between subunits are not known.

Random matrix theory has been applied extensively in studying multiple financial time series [20-24].

In order to quantify correlations, we first calculate the logarithmic return of the ith cryptocurrencies price series over a time scale Δt,

$$r(t) = \ln x_i(t) - \ln x_i(t - \Delta t), \qquad (16)$$

where $x_i(t)$ denotes the price of ith cryptocurrency at time t. In this work, we present the results for daily returns with $\Delta t = 1$ day. It was selected 15 cryptocurrecies for the period from 01.06.2017 to 23.04.2018. The database includes the following cryptocurrecies: Bitcoin – BTC, Ethereum – ETH, Ripple – XRP, Stellar – XLM, Litecoin – LTC, Vechain – VEN, Monero – XMR, NEM – XEM, Ethereum Classic – ETC, Lisk – LSK, Gnosis – GNO, Qtum – QTUM, BTM – BTM, Dash – DASH, BitConnect Coin – BCCOIN (https://finance.yahoo.com/cryptocurrencies).

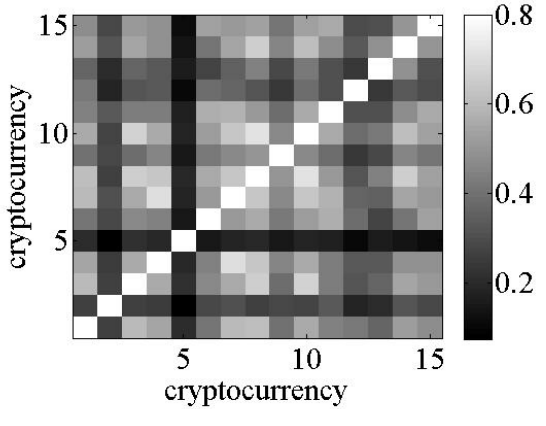
We calculate the pairwise cross-correlation coefficients between any two cryptocurrencies returns time series. For simplicity, the original returns for each cryptocurrencies time series are standardized as follows:

$$g_i(t) = \frac{r_i(t) - \langle r_i(t) \rangle}{\sigma_i}, \quad (17)$$

where $\langle \cdot \rangle$ denotes the time average of a given time series and $\sigma_i = \sqrt{\langle r_i(t)^2 \rangle - \langle r_i(t) \rangle^2}$ is the standard deviation of $r_i(t)$. We then compute the equal-time cross-correlation matrix C with elements

$$c_{ij} = \langle g_i(t) g_j(t) \rangle . \quad (18)$$

In fig. 2 for comparison, correlation maps for the original matrix and random.



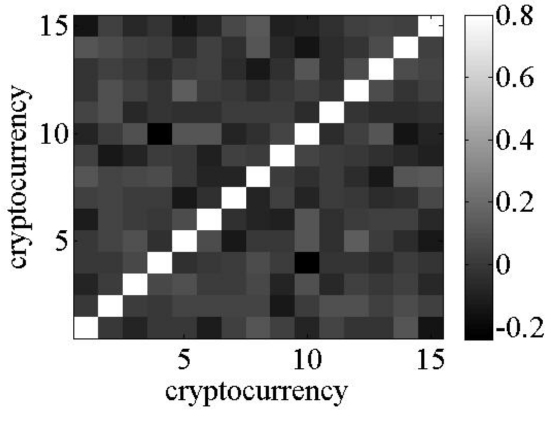


Fig. 2. Grayscale pixel representation of the cross-correlation matrix c_{ij} for the original matrix (a) and random matrix (b). Here, the gray scale coding is such that black corresponds to c_{ij}=0 and white corresponds to c_{ij}=1.

Obviously, the original matrix is much more correlated. This is evidenced by fig. 3, which contains a comparison of the distribution of correlation coefficients of the original and random matrices and indicates significant fluctuations of the pair correlation coefficients.

For the correlation matrix C we can calculate its eigenvalues,

$$C = U \Lambda U^T , \tag{19}$$

where U denotes the eigenvectors, Λ is the eigenvalues of the correlation matrix, whose density $f_c(\lambda)$ is defined as
follows [23],

$$f_c(\lambda) = \frac{1}{N}\frac{dn(\lambda)}{d\lambda}, \tag{20}$$

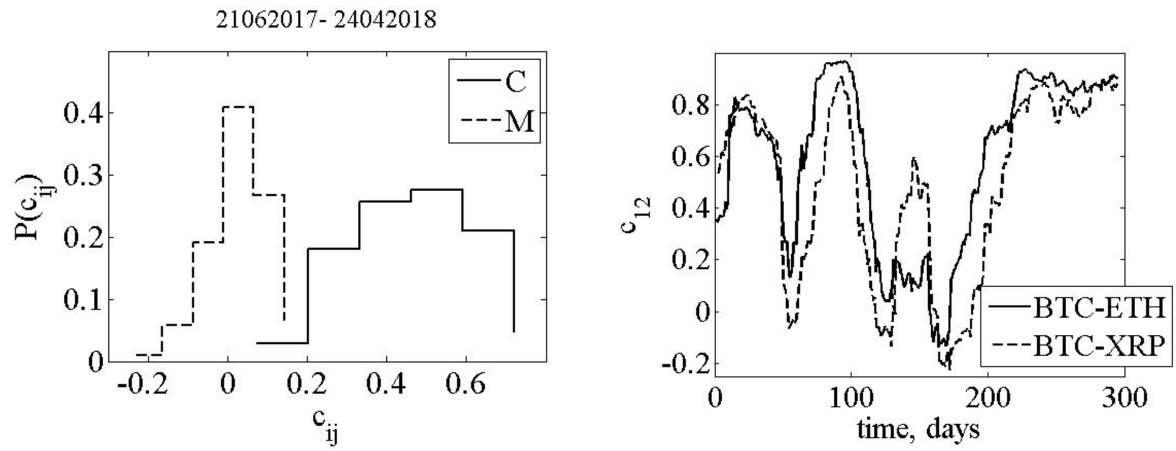
where $n(\lambda)$ is the number of eigenvalues of C that are less than λ. If M is a T by N random matrix with zero mean and unit variance, $f_c(\lambda)$ is self-averaging. In particular, in the limit $N \to \infty$, $T \to \infty$ and $Q = T / N \geq 1$ fixed, the probability density function $f_c(\lambda)$ of eigenvalues λ of the random correlation matrix M has a close form [21]:

$$f_c(\lambda) = \frac{Q}{2\pi\sigma^2}\frac{\sqrt{(\lambda_{\max} - \lambda)(\lambda - \lambda_{\min})}}{\lambda} \tag{21}$$

with $\lambda \in [\lambda_{\min}, \lambda_{\max}]$, where $\lambda_{\min}^{\max}$ is given by

$$\lambda_{\min}^{\max} = \sigma^2 (1 + 1/Q \pm 2\sqrt{1/Q}), \tag{22}$$

and σ^2 is equal to the variance of the elements of matrix M.

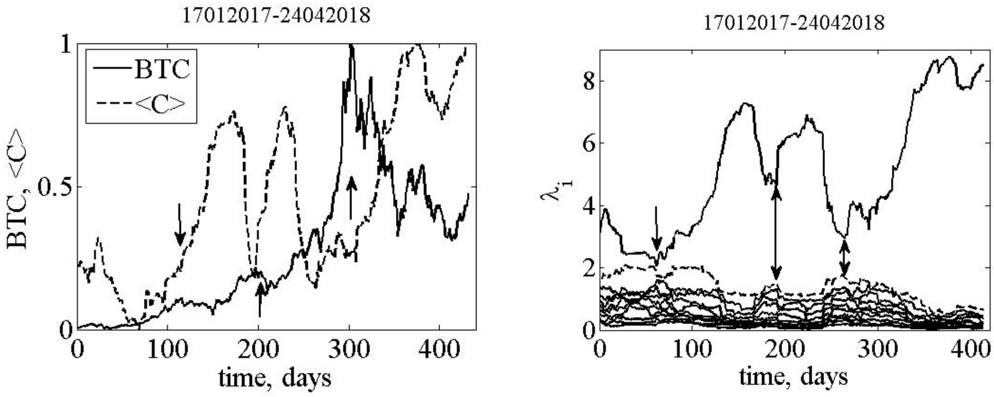


a) b)

Fig. 3. a) Distribution of correlation coefficients original matrix C and random matrix M. b) Time dependence of correlation coefficients "Bitcoin - Ethereum " and " Bitcoin - Ripple"

We compute the eigenvalues of the correlation matrix C, $\lambda_{\max} = \lambda_1 > \lambda_2 > \cdots > \lambda_{15} = \lambda_{\min}$. We find that the largest eigenvalue $\lambda_{\max}$=6.99 and the smallest eigenvalue $\lambda_{\min}$= 0.21. (2-7-RMT, 1/3). If C is a random matrix, the largest eigenvalue $\lambda_{\max}^{RMT} = 1.58$ and the smallest eigenvalue $\lambda_{\min}^{RMT} = 0.55$, according to Eq. (22). In our case, only one-third of its own values refer to the RMT region.

Random matrix theory is in essence equivalent to principal component analysis because both of them deal with the correlation matrix and its eigenvalues. Under the framework of random matrix theory, if the eigenvalues of the real time series differ from the prediction of random matrix theory, there must exist hidden economic information in those deviating eigenvalues. For cryptocurrencies markets, there are several deviating eigenvalues in which the largest eigenvalue reflects a collective effect of the whole market. This is evidenced by the results presented in Fig. 4.



a) b)

Fig. 4. a) Average value of the correlation coefficients $< C >$, calculated from 15x15 correlation matrices C constructed from daily returns using a sliding 50 days time window in discrete steps of one day and bitcoin time series for the comparable period; b) spectrum of eigenvalues of the matrix C. Relevant critical and crisis phenomena are marked with arrows

We find that both $< C >$ and $\lambda_{\max}$ have large values for periods containing the market crash. At the same time, their growth begins in the pre-crisis period. Means, as well as the economic mass, they are quantum precursors of crisis phenomena

4 Conclusion

Consequently, in this paper, we have shown that monitoring and prediction of possible critical changes on cryptocurrency is of paramount importance. As it has been shown by us, the quantum econophysics has a powerful toolkit of methods and models for creating effective indicators-precursors of crisis phenomena. In this paper, we have explored the possibility of using the Heisenberg uncertainty principle and random matrix theory to detect dynamical changes in a complex time series. We have shown that the economic mass m, average value of the correlation coefficients $< C >$ and the largest eigenvalue $\lambda_{\max}$

may be effectively used to detect crisis phenomena for the cryptocurrencies time series. We have concluded though by emphasizing that the most attractive features of the m, $<C>$ and $\lambda_{\max}$, namely its conceptual simplicity and computational efficiency make it an excellent candidate for a fast, robust, and useful screener and detector of unusual patterns in complex time series.

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1.19. Дослідження зовнішньої стійкості економіки України: сигнальний підхід

Для дослідження зовнішньої стійкості економіки України актуальним питанням виступає побудова системи її індикаторів та їх аналіз.

У даному дослідженні для аналізу системи індикаторів зовнішньої стійкості економіки України запропоновано використання сигнального підходу для розрахунку порогових персентилей, ймовірностей появи нестабільності внаслідок впливу зовнішніх збурень та співвідношення шум-сигнал для кожного показника зовнішньої стійкості української економіки. Також для кожної групи показників та системи індикаторів зовнішньої стійкості економіки України в цілому необхідним є розрахунок середніх ймовірностей появи нестійких ситуацій за умови сигналу від індикаторів та без його урахування на основі сигнального підходу.

На основі аналізу літературних джерел [1]-[4], [6], [15] для аналізу зовнішньої стійкості економіки України відібрано індикатори, які було поділено на п'ять груп: макроекономічні індикатори, індикатори, що характеризують позицію по рахунку поточних операцій, індикатори, що характеризують позицію по капітальному рахунку, боргові індикатори та індикатори, що характеризують вплив зовнішнього сектору.

Розрахунок порогових персентилей для індикаторів зовнішньої стійкості економіки України було здійснено на основі методики [13] з використанням сигнального підходу, описаного у роботах [5], [9]-[12].

Так, порогові персентилі для кожного індикатора зовнішньої стійкості розраховуються наступним чином:

$$\alpha = 1 - \frac{A+B}{n}, \quad (1)$$

де α - пороговий персентиль,
$A+B$ - кількість правильних сигналів індикатора,
n - кількість спостережень.

Результати розрахунків порогових персентилей наведено у таблиці 1.

ВІДОМОСТІ ПРО НАУКОВИЙ АВТОРСЬКИЙ КОЛЕКТИВ

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РОЗДІЛ 2. ЕКОНОМІЧНЕ ПРОГНОЗУВАННЯ ТА УПРАВЛІННЯ КУРОРТНИМИ РЕКРЕАЦІЯМИ І ТУРИЗМОМ В РЕГІОНАХ

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РОЗДІЛ 3. МОДЕЛІ «ЗЕЛЕНОЇ ЕКОНОМІКИ» ТА «SMART CITY»

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ANNOTATION

Chernyak O., Chernyak Yev., Shevchuk Yev. Estimation of investment efficiency in the economy of Ukraine in 2012-2017 from the positions of the theory of evolutionary processes

Using the theory of evolutionary processes, the dynamics of investment efficiency in the Ukrainian economy during 2012-2017 was investigated. The efficiency of investments during this period was rather low, they did not exceed 35%, and were only 15% in the average.

Vitlinskyi V. Problems of taking into account conflict of risks and their prediction in the new economy.

The development of the modern economy requires special attention to the problems of risk, sustainability, security, ensuring an adequate level of viability of economic systems. There are several types and types of risks of a new (digital) economy, which are in a conflict situation with each other. It is proposed to bring all these risks to an acceptable degree, using for this a hierarchical game theory tool, in which the interests of the parties are not exactly the opposite. It is about using the concept and theory of singularity for modeling and predicting rare events, phenomena, processes, the relevance of machine learning and methods and models of nonlinear economic dynamics.

Babenko V., Nakisko A., Rudenko S. Enhancement of economic efficiency of agricultural production on the basis of agricultural information management information management.

The theoretical and methodical approaches to the realization of the task of increasing the economic efficiency of agricultural production on the basis of the application of systems of information management of the production activity of agricultural enterprises for the production of agricultural products are investigated. On the basis of modern information technologies, a system of information support for the optimization of production activity management of domestic agro enterprises has been designed and developed, which has been proven in the activity of enterprises for the production and processing of agricultural products of the Kharkiv region.

Hrytsiuk P. Mathematical modeling of the earth population growth.

The article proposes a logistic paradigm for the demographic systems development. Mathematical models for the Earth population growth and for its individual continents have been constructed.

Guryanova L., Klebanova T. Modeling the influence of σ-convergence indicators on the macro-indicators dynamics

The paper suggests a methodical approach to the formation of a model basis for assessing the unevenness of regional development as a threat to sustainable development of the economy, which is based on methods of σ-convergence analysis, multidimensional analysis, econometric modeling, production-institutional functions, and allows to identify the dominant factors of increasing regional development unevenness, to assess the impact of the threat of increased regional development unevenness on the macroeconomic indicators dynamics.

Kovalchuk K., Prykhodchenko O. Forecasting the coefficient of location pension system in understanding conditions.

The pension system of Ukraine in terms of adequacy of pension payments in conditions of uncertainty is analyzed in the article. Uncertainty and risk factors in pension systems are described. The analysis of the pension size and the replacement rate of the last salary by the pension from the PAYG system in 2018 by types of economic activity was carried out. The scenario analysis of the replacement rate of the last salary pension from the accumulation system is given.

Konishcheva N., Tkachova S. Progressive social development: problems of definition and measurement.

The purpose of this study was to clarify the content of the concept of progressive social development on the basis of ideological orientations of society and the formation of new approaches to its measurement.

Maksishko N., Bilenko V. Pre-foreseeable analysis of dynamics prices for wheat wines in Ukraine.

The article analyzes the concept "Ukraine - the breadbasket of Europe". It is proved that cereal production is currently a possible locomotive for the growth of the Ukrainian economy. A statistical analysis of prices for winter wheat has been carried out. It was found that prices and yields of winter wheat are not subject to normal distribution. The execution of tests for deterministic chaos and fractal analysis, in turn, confirmed the presence of the internal structure in the ranks of the studied dynamics. The depth of memory of time series of the price and yield of winter wheat is calculated. The basis of future research is the forecast for winter wheat and fundamental analysis of the factors influencing the price of winter wheat.

Merkulova T., Akulova A. Multiagental model of packing competition: prespoting and experiment.

The paper presents the main assumptions of the developed multiagent model of tax competition, its applications for research on various aspects of this phenomenon and the analysis of the results of the two simulation experiments carried out.

Oleinik V. Modeling of portfolio on the basis of Var indicator.

This article describes a formation of various portfolios models based on H. Markovitz portfolio theory. The portfolios, which can include instruments with fixed profitability and common stock are considered. As a risk measure VaR indicator is used. In these optimization models maximization of portfolio efficiency at the set risk level and risk minimization at the set level of efficiency can act as criterion functions. In some optimization tasks efficiencies of risky assets are calculated considering market changes. Numerical results of effective assets distribution within the portfolio for various optimization problems statements are shown.

Bożena Gajdzik. Methodology of forecasting steel production in situation of using two key technologies of production.

The article is about innovation methodology used in forecasting of volume steel production when the production process is realized by two key technologies. In Polish steel industry and in other countries in the world are used two processes: BF+ BOF (converters) and EAF (electric process). Production of BOF steel and EAF steel create all volume of steel production. The share of steel from the BF/BOF process is higher than EAF steel (for example, the share of steel from the BF/BOF process is higher than 50% in Poland).

Tadeusz Pokusa, Kacper Pokusa, Filip Pokusa. Powstanie Euroregionu „PRADZIAD" i jego struktura przestrzenna.

Podsumowując kwestię powstania, struktury przestrzennej i podmiotowości współpracy transgranicznej w formie euroregionów na przykładzie Pradziada, należy powiedzieć, ze w organizowaniu współpracy decydującą rolę odegrały tu samorządy terytorialne (gminy, powiaty, województwa). Mają one bowiem osobowość prawną i mogą występować zarówno jako podmioty prawa cywilnego jak i podmioty prawa publicznego. Mogą występować ponadto, w formie grupowej i w ten sposób objąć zakresem współpracy znacznie większe terytorium. Mają prawo tworzyć związek międzykomunalny lub stowarzyszenie. We wszystkich tych konfiguracjach mogą podejmować także współpracę o szerokim zakresie przedmiotowym.

Porokhnya V., Ivanov R. Influence of inflation on economic behavior of households of Ukraine.

Separate questions of formation of inflationary processes are considered. Strategies for economic behavior of households in conditions of creeping and galloping inflation. Differences between the cognitive and reflexive component of the formation of economic behavior are noted. The results are coordinated with statistical data.

Porokhnya V., Oharenko T. Methodology of designing a logistics system for modeling production processes at an enterprise.

The main problem of managing logistics processes at the enterprise is time and modeling. Firstly, is the production management system able to formulate the structure of the logistics system online, evaluate its simulation results and modify a set of options for improving its efficiency? Secondly, is there a tool available to satisfy the logistics system's ability to obtain the desired results by simulation?

The design methodology and mechanism of constructing a logistic system with subsystems has been developed, which makes it possible to establish and visualize its structure and functional connections between subsystems.

The developed methodology and concept of application of methods and models in the modeling of logistic processes at the enterprise allow you to simplify the process of designing a logistics system for a single company by systematizing the processing of input data and the effective application of methods and models of simulation model of simulation of logistic processes.

Porokhnya V., Ostapenko A. Optimization model for forecasting the distribution and use of budget funds for programs of development of the Armed Forces of Ukraine in the conditions of economic instability.

The result of the evaluation of the effectiveness of the UAF on the basis of the utility function was the optimization model for allocating budget funds to the programs of development of the Armed Forces of Ukraine, built on the basis of the linear programming method in the presence of limitations for each defense budget allocation program, which takes into account the levels of the long-term development of the program and the probability of its provision, the practical use of which makes it possible to approach the NATO standards in the budget and provides the ability to predict underperformance of the budget in the risk of its use.

Pursky O., Kharchenko O., Mazoha D. Methods for clustering of electronic trade market consumers.

In this work, the applying’s problematics of the different clustering methods for classifying e-trade consumers according to consumer priorities is discussed. The main mechanisms of the methods of clear and fuzzy clustering are determined. Algorithms for clustering data on e-commerce customers are investigated and their advantages and disadvantages are determined. The algorithms choice for the clustering of e-trade customers should be based on the application of methods of verification, visualization and recognition of clustering data.

Ramazanov S. Forecasting and managing innovative economy on the basis of integrated stochastic model in the phase space.

In order to predict the development of the state of the innovation economy, an integrated stochastic nonlinear model of growth dynamics in the phase space was developed and investigated. In this paper, aspects of optimization of the management of the activity of modern complex systems that function and develop under the current conditions of instability are considered.

Soloviev V., Solovieva V. Quantum econophysics of cryptocurrencies crises.

From positions, attained by modern theoretical physics in understanding of the universe bases, the methodological and philosophical analysis of fundamental physical concepts and their formal and informal connections with the real economic measuring is carried out. Procedures for heterogeneous economic time determination, normalized economic coordinates and economic mass are offered, based on the analysis of time series, the concept of economic Plank's constant has been proposed. The theory has been approved on the real economic dynamic's time series, related to the cryptocurrencies market, the achieved results are open for discussion. Then, combined the empirical cross-correlation matrix with the random matrix theory, we mainly examine the statistical properties of cross-correlation coefficient, the evolution of average correlation coefficient, the distribution of eigenvalues and corresponding eigenvectors of the global cryptocurrency market using the daily returns of 15 cryptocurrencies price time series across the world from 2016 to 2018. The result indicated that the largest eigenvalue reflects a collective effect of the whole market, practically coincides with the dynamics of the mean value of the correlation coefficient and very sensitive to the crisis phenomena. It is shown that both the introduced economic mass and the largest eigenvalue of the matrix of correlations can serve as quantum indicator-predictors of crises in the market of cryptocurrencies.

Bazhenova O. Research of external stability of Ukraine's economy: signal approach.

Based on the signal approach the threshold percentiles, the probabilities of instability occurrence due to external disturbances and the noise-signal ratio for each indicator of external sustainability for the Ukrainian economy are calculated. For each of the five groups of indicators and the indicators' system in a whole it is calculated the average probabilities of unstable situation occurrence under the condition of a signal from indicators and without it.

Glushchevsky V. Applied aspects of application of stratification metamodeling technology in commercial bank management systems.

In this article author highlighted his modeling concept of systems of adaptive management of microeconomics systems, which is based on developed methodology of stratificational metamodeling. The author justified instrumental capability and perspectives of appliance of stratificational metamodeling methodology regarding integration of IT-implementation of corresponding modeling software with existing corporate ICS. This work laid the foundation for further scientific research towards development of stratificational metamodeling tools for microeconomics systems related to Section K – «Financial and insurance activities»: the author did conceptualization of theoretical statements and developed system of economical and mathematical management models of banking institution income.

Savushkin D. Motivation system of labor organization, as a key company of transformation of activity of the company.

Employee motivation of employees is one of the most important factors which allow to achieve a significant increase in productivity. The most important role of employees motivation belongs to the methods of material and non-material stimulation. Research of practical experience of effective companies suggests that the issue of productivity growth can be solved by developing and implementing an integrated system of employee motivation, which enables to significantly improve the quality and efficiency of work. The success of the work on the creation and implementation of an integrated system of employee motivation depends to a large extent on the head of the organization, which plays a main role in the process of all changes in the company.

Spyrko V., Potapenko A. Modeling process of the defense of born shoots at the factoring operations for the additive algorithm DATA MINING.

The article defines the concept of debt and debt portfolios, outlines the legal basis for the activities of the collection company. The description of the activity of the collector company and the principle of work on debt repayment are presented. The problem, the solution of which in case of debt recovery can be reduced to a model of classification, is described. To solve the problem, Data Mining algorithms are used, which, using the classification of debt portfolios, evaluate the prospects of working with them and profit. The principle of the application of such models as, the method of the nearest neighbors, the naive Bayesian classifier, gradient boosting and the random forest method are shown.

Zakharchenko P., Zakharchenko O. Evolutional changes of economic systems.

The article is devoted to solving of problem the researches of mechanism to diffuse in activity of socioeconomic systems. There are reflected peculiarities of their activity in market conditions, and there are grounded necessity and methodology of construction of dynamic model of functioning of the systems with diffuse properties.

Zhvanenko S. Model of innovative development of the economy of the national resort and recreational complex.

The article is devoted to solving of actual problem the forming of effective mechanism of management innovative activity national resort-recreation to the complex. It is offered and in theory grounded conception of innovative development on the basis of model analysis of influence of innovations on development resort-tourist spheres in the conditions of transformation economy. On its basis, the model of passing is built to the innovative product resort-recreation complex at existing at the market traditional products. Built and investigational model of receipt of discounted profit in the conditions of innovative activity taking into account a competition, the scenario of innovative development is got.

Kardashova T. The models of the optimization of resort-recreation potential.

There is offered the methodology of creation of adaptive management models, which are presented as a spectrum of dynamic models of the optimum programs construction of resort-recreation products production, and allow to react on changing materially - streams of raw materials and to expect the optimum load of medical base.

Kirkova N. Marakhovskiy A. Patterns of the functioning of resort-recreation systems.

The article is devoted to the study of system characteristics in the activities of enterprises of the resort and recreation sphere on the basis of systems analysis methods. The features of sanatorium activity in the market conditions are shown, necessity and methodology of dynamic models of management of their development are grounded, as well as results of research on the example of the resort complex in Berdyansk.

Kostenko G. Integral assessment of financial support for the development of sanatorium-resort facilities.

The aim of the research is to improve the methodological approach for a comprehensive assessment of the financial provision of sanatorium and spa establishments on the basis of the development of an integral indicator.

Ladunka I. Economic mechanism of the enterprise: the satisfaction on improvement success.

The article deals with the concept of economic mechanism and its main characteristics. The structure and principles of construction of the internal economic mechanism of the enterprise are investigated. The necessity of constructing a model of improvement of the internal economic mechanism in order to ensure economic development of the enterprise is substantiated.

Lemish K., Babina N. Modern tendencies of professional training of future specialists the hospitality industries of the country and the region.

The purpose of the study is to determine the current trends in the professional training of future specialists in the hospitality industry of the country and the region.

Tokarenko O., Shvachko V. Backgrounds for formation of the modern concept of development of the resort representation and tourism business in Ukraine.

This article provides an analysis of the factors that influence the formation of a modern concept for the development of recreation and tourism business in Ukraine. Particular attention is paid to the analysis of historical preconditions for the establishment of the sanatorium and resort area of Ukraine, as well as to the current trends in the market of services, including in the spa industry, the experience of overseas resorts that influence the formation of organizational and economic, administrative mechanisms for managing the development of the resort recreational and tourist business in Ukraine.

Cheremisina T., Lemish K. Features of innovative management and directions for developing innovations in tourism.

The issue of determination of innovation management and innovation processes in various spheres of economy is investigated. The tourist sphere, like any other, needs modern methods, forms and mechanisms of service. In order to withstand the competition in the tourism market, enterprises of the tourism sector must implement innovative management, thus providing high-quality tourist services. The issues of specificity and features of innovative management in the tourism sector are considered. The innovative management in the field of tourism is defined as a modern system of development, development and management of tourism innovations, investments made by owners in the development of all types of innovations, and a mechanism for managing these processes aimed at improving and developing the object of management and increasing its capital. The processes of management of innovations in the tourism sphere and world practice are named. They are called innovative processes, the practical potential of which is largely determined by the level of development of tourist innovative infrastructure.

Zakharchenko P., Mukhin V. Models of green economy in the resort-tourism sphere: problems and prospects.

The purpose of this article and its main task is to systematize the directions of environmentally oriented development of economic actors in the context of the "green" economy, as well as to determine the list of key provisions and approaches of the "green" economy, which will ensure the further sustainable economic development of the resort and tourist sector of Ukraine. As methodology of research methods of system analysis, as well as comparative and economic-statistical methods of analysis are used.

Glazova Ya. Analysis of indicators of sustainable development of Ukraine in the context of the "green" economy.

The article examines the prospects for developing the "green" economy in the context of the implementation of the concept of sustainable development. The paper is devoted to the study of the current state and dynamics of the distribution of tools and mechanisms of "green" economic development. The world tendencies of sustainable development and their adaptation to the conditions of Ukraine are analyzed in the context of diversification of the structure of the economy aimed at modernization taking into account environmental aspects, increasing energy efficiency and the development of renewable energy sources.

Gorpinich O. Land relations and their ecological component in agriculture of Ukraine..

Effective and ecologically oriented functioning of the agrarian sector of the economy, due to its features, requires the development and implementation of various regulatory instruments. Market regulation affects the state of the agrarian economy through objective market laws and regularities such as competition, laws of supply and demand, the law of value, the law of unlimited need for limited resources, etc. This influence occurs in the conditions typical of market relations: private property, freedom of business and choice, competition and personal interest. The regulation of agrarian production only by market incentives aimed at obtaining the greatest possible profits leads to a distortion of the balance in economic and environmental systems.

Gritsenko M. Green economy as achievements stability in Ukraine.

The "green" economy is based on alternative sources of energy and fuel, cleaner production technology, clean technologies in farming, green building, as well as programs for the purification of air, water and soil from pollution, recycling and utilization of waste, etc. Many scientists are investigating this topic, developing new concepts. It is the "green economy" that can become a source of development for Ukraine as a whole and its individual regions. Consequently, the prospects for creating a green economy in Ukraine become necessary and quite achievable.

Наукове видання

ПРИКЛАДНІ АСПЕКТИ ПРОГНОЗУВАННЯ РОЗВИТКУ ЕКОНОМІКИ УКРАЇНИ

Монографія

За редакцією: О.І. Черняка, П.В. Захарченка