General information product theory in economics science

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Abstract – The information, including the knowledge in the science, business and society, is being generated, transmitted, received and analyzed by the humans in the various countries over the centuries. The information is a most valuable asset in possession by the economic agents in the modern economies of the scales and scopes in the information societies in an information age. The authors introduce a notion on the general information product (GIP) in the macroeconomics, thoughtfully defining the GIP in the frames of the Ledenyov theory on the GIP(t) in the economies of scales and scopes for the first time. The multiple possible origins of the fluctuations of the dependence of the general information product on the time GIP(t) in the economies of scales and scopes are researched comprehensively. Authors consider the GIP(t) as a main parameter, which evaluates the performance of the economies of the scales and scopes from macroeconomics perspective. Authors assume that the accurate characterization of the dependence GIP(t) can be made in agreement with the Ledenyov theory on the GIP(t) in the economies of scales and scopes. Authors believe that the Ledenyov indicator GIP(t) instead of the Kuznets indicator GDP(t), can be successfully used to accurately measure the state/performance by any economy of scale and scope in the time domain. Authors think that the GIP(t) is a discrete-time digital signal (the Ledenyov digital wave), but it is not the continuous-time signals (the continuous waves), because of the discrete digital nature of information generation process. The article considers the empirical theoretical approaches and reveals the possible practical technical limitations in relation to the modeling of the new types of the discrete-time digital signals generators for the Ledenyov digital waves generation in the economies of the scales and scopes at the time of globalization.

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Keywords: dependence of general information product on time GIP(t), dependence of general domestic product on time GIP(t), discrete-time digital waves, discrete-time digital signals generators, spectrum analysis / amplitude / frequency / wavelength / period / phase of discrete-time digital signal, mixing / harmonics / nonlinearities of discrete-time digital signal, continuous-time signals, Juglar fixed investment cycle, Kitchin inventory cycle, Kondratieff long wave cycle, Kuznets infrastructural investment cycle, econophysics, econometrics, nonlinear dynamic economic system, economy of scale and scope, macroeconomics.
Introduction


There are the five main types of the business cycles in the modern macroeconomics science, which are originated by various kinds of the fluctuations of the economic variables in the economies of the scales and scopes:

1. 3 – 7 years Kitchin inventory cycle in Kitchin (1923);
2. 7 – 11 years Juglar fixed investment cycle in Juglar (1862);
3. 15 – 25 years Kuznets infrastructural investment cycle in Kuznets (1973a, b);
4. 45 – 60 years Kondratieff long wave cycle in Kondratieff, Stolper (1935); and
5. 70+ Grand super-cycle.

The key research idea in the modern macroeconomics science that the dependence of the General Domestic Product on the time GDP(t) can be used with the aim to better
characterize the macroeconomic processes in the economies of scales and scopes has been suggested in Kuznets (1973a, b).

The key discovery in the modern macroeconomics science is that the Ledenyov digital waves (the discrete-time digital signals) rather than the early considered continuous waves (the continuous-time signals) originate and propagate in the nonlinear dynamic economic system in the time domain in Ledenyov D O, Ledenyov V O (2015e). The Ledenyov digital waves may have the multiple origins and they can be generated by the discrete-time economical, financial, political and social events in the economies of scales and scopes in the time domain in Ledenyov D O, Ledenyov V O (2013c, 2015d, 2015e).

In this research article, the authors would like to highlight an interesting observation that the information streams are being constantly generated by the economic agents in all the existing real and imaginary economic sectors of the modern economies of the scales and scopes in the information societies in 21st century. Therefore, aiming to reflect the essential aspect of changing economic reality, the authors introduce a notion on the general information product GIP(t) in the macroeconomics, thoughtfully defining the dependence GIP(t) in the frames of the Ledenyov theory on the GIP(t) in the economies of scales and scopes for the first time. Then, the authors consider the GIP(t) as a main parameter to evaluate the performance of the economies of the scales and scopes in the information societies. As a result, the authors come up with the important proposal that it necessary to use the general information product GIP(t) instead of both the general domestic product GDP(t) or the general national product GNP(t) with the purpose to accurately evaluate the performance of the economies of the scales and scopes in the information societies at the time of globalization.

Accurate characterization of dependence of general information product on time GIP(t) in economies of scales and scopes in information societies

The information in the form of a numerical measure of knowledge has been researched in the frames of the information theory in the information science, which is concerned with the scientific thinking on the generation, gathering, classification, transmission, storage, retrieval and analysis of the acquired bits of information, using the information communication science in Maxwell (1890), Gabor (1946), Shannon (1948), and the probability science in De Laplace (1812), Bonyakovksy (1846), Chebyshev (1846, 1867, 1891), Markov (1890, 1899, 1900, 1906, 1907, 1908, 1910, 1911, 1912, 1913), Kolmogorov (1938, 1985, 1986), Wiener (1949), Brush (1968, 1977), Shiryaev (1995).


Let us begin by saying that the macroeconomics, which has been considered as an empirical science for long time in Krugman, Wells (2005), Stiglitz (2005, 2015), Desai, King, Goodhart (2015), is being transformed into the multidisciplinary econophysical / econometrical science presently. In the macroeconomics, the authors would like to introduce the notion on the general information product GIP(t), which represents the dependence of the general information product (GIP) on the time in the frames of the Ledenyov theory on the GIP(t) in the economies of scales and scopes for the first time. The dependence of the general information product (GIP) on the time can be interpreted as the dependence of the measured total information data stream over the finite time period (bits per month/quarter/year) in Hwang, Briggs (1984), Anceau (1986), Fountain (1987), Chen (editor) (1988), Van de Goor (1989),
The measured information has to include all the data at the multiple information layers, which are generated by the acting economic agents within the selected economy of the scale and scope over the finite time period.

In other words, the authors would like to state that the **GIP(t) is a main parameter, which evaluates the performance of the economies of the scales and scopes from the macroeconomics perspective**, hence the Ledenyov economic indicator: the general information product per the time GIP(t), instead of the Kuznets economic indicator: the general information product per the time GDP(t) in Kuznets (1973a, b), has to be successfully used to accurately measure the state of any economy of scale and scope in the time domain.

Going from the economic point of view, the **five main possible origins of the discrete-time fluctuations of the dependence of the general information product on the time GIP(t)** in the economies of scales and scopes can include:

1. Discrete-time fluctuations in the technical innovation appearance;
2. Discrete-time fluctuations in the financial capital availability;
3. Discrete-time fluctuations in the qualified/unqualified labour access;
4. Discrete-time fluctuations in the resources presence;
5. Discrete-time fluctuations in the political and social regimes.

In general, the **information streams with the discrete-time nature** are being constantly generated by the various economic agents in all the existing real and imaginary economic sectors of the modern economies of the scales and scopes in the information societies in 21st century. Therefore, taking to the consideration the oscillating nature of GIP(t), the authors think that the GIP(t) is a discrete-time digital signals (the Ledenyov digital waves), but it is not the continuous-time signals (the continuous waves), because of the discrete-time digital nature of the information generation process.

The example of the over-damped distorted discrete-time digital signal is shown in Fig. 1 and the example of the reconstructed discrete-time digital signal is shown in Fig. 2.

Moving to the next point, let us focus on the **empirical theoretical approaches** and reveal the possible practical technical implementations and their possible limitations as far as the modeling of the **new types of the discrete-time digital signals generators** for the **Ledenyov digital waves generation** in the economies of the scales and scopes at the time of globalization is concerned.
Fig. 1 shows an example of the over-damped distorted discrete-time digital signal in Matlab (R2012).

![Fig. 1. Example of over-damped distorted discrete-time digital signal (after Matlab (R2012)).](image1)

Fig. 2 displays an example of the reconstructed discrete-time digital signal in Matlab (R2012).

![Fig. 2. Example of reconstructed discrete-time digital signal (after Matlab (R2012)).](image2)
The computer modeling is performed with the use of the recently developed discrete-time digital wave generation model, which can be described by the mathematical expression:

\[ y_i = A_i \sin\left(2\pi f_i t + \phi_i\right), \]

where \( BPSK : \phi(t) = 1, 2 \)

\[ QPSK : \phi(t) = 1, 2, 3, 4 \]

\[ MPSK : \phi(t) = 1, 2, 3, 4, \ldots, i. \]

Fig. 3 shows a visual representation of the discrete-time digital signal, which is generated by the Binary Phase Shift Keying (BPSK) with the phase \( \phi(t) = 1, 2 \) in Matlab (R2012).

![Fig. 3. Visual representation of discrete-time digital signal generated by Binary Phase Shift Keying (BPSK) with \( \phi(t) = 1, 2 \) (after Matlab (R2012)).](image)

In this research work, the developed experimental set up for the practical implementation of the discrete-time digital signal generator to model the dependence of the general information product (GIP) on the time, which is originated by the discrete-time oscillations of the economic variables in the economies of the scales and scopes includes:

1) the baseband generator, which creates the baseband waveform to drive the IQ modulator;

2) the IQ modulator (the In-Phase and Quadrature modulator), which modulates the discrete-time digital signal;

3) the high precision timer, which provides the time reference.
Changing the phase of digital signal discretely with the application of the Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) and other high order digital modulation techniques (16PSK, 32PSK, 64PSK), it is possible to generate the discrete-time digital signals with the complex waveforms to model the oscillations of the economic variables in the economies of the scales and scopes in Rice (2008).

Fig. 4 depicts the visual representation of the in-phase and quadrature components of the modulated signal constellation at the Quadrature Phase Shift Keying (QPSK) with $\phi(t) = 1, 2, 3, 4$ in Matlab (R2012).

![Fig. 4. Visual representation of in-phase and quadrature components of modulated signal constellation at Quadrature Phase Shift Keying (QPSK) with $\phi(t) = 1, 2, 3, 4$ (after Matlab (R2012)).](image)

The quality of the discrete-time digitally modulated signal with the complex waveform has been estimated by measuring:

1) the signal error vector magnitude (EVM) by computing the magnitude difference between the ideal reference signal and the measured signal on the IQ constellation diagram;

2) the signal error phase (EP) by computing the phase difference (the angle) between the ideal reference signal and the measured signal on the IQ constellation diagram.
Fig. 5 displays the in-phase and quadrature components of the modulated signal constellation, showing a presence of the error vector magnitude at the Quadrature Phase Shift Keying (QPSK) with $\phi(t) = 1, 2, 3, 4$ in Matlab (R2012).

**Fig. 5.** Visual representation of in-phase and quadrature components of modulated signal constellation, showing presence of error vector magnitude at Quadrature Phase Shift Keying (QPSK) with $\phi(t) = 1, 2, 3, 4$ (after Matlab (R2012)).

Fig. 6 shows the in-phase and quadrature components of the modulated signal constellation, showing presence of the error vector magnitude at the 16 Quadrature Amplitude Modulation (16 QAM) with $\phi(t) = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16$ in Matlab (R2012).

**Fig. 6.** Visual representation of in-phase and quadrature components of modulated signal constellation, showing presence of error vector magnitude at 16 Quadrature Amplitude Modulation 16 QAM with $\phi(t) = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16$ (after Matlab (R2012)).
The spectral analysis of the discrete-time digital signals has been performed with the application of the Discrete Fourier Transform (FT), Discrete Cosine Transform, z-Transform, Discrete Wavelet Transform, Discrete Walsh-Hadamard transform mathematical techniques by transforming the signal’s dependence of the amplitude on the time in the time domain to the signal’s dependence of the amplitude on the frequency in the frequency domain so that the energy of the discrete-time digital signal is assumed to be concentrated in the corresponding coefficients. Fig. 7 presents the conception demonstration of the Discrete Fourier Transform (DCT) of discrete-time digital signal in Matlab (R2012)).

![Discrete Fourier Transform](image)

**Fig. 7.** Conception demonstration on Discrete Fourier Transform of discrete-time digital signal (after Matlab (R2012)).

It may worth to note that our experimental setup to generate and analyse the discrete-time digital signals includes the following measurements equipment: HP ESG signal generator, Rhode and Schwartz spectrum analyzer, Tektronix oscilloscope, Lenovo lap top computer with the GPIB board, and it was configured and calibrated in agreement with the spectrum analysis principles and techniques in Witte (1993, 2001). The obtained dependences of the general information product on the time GIP(t) for the G20 economies of the scales and scopes have been developed, analyzed and discussed subtly. These dependences GIP(t) represent a certain scientific interest, because of some reasons, hence they will be discussed in our next research article at later time. Comparing the GIP(t) method and the GDP(t) method, the authors came to one important result that the characterization method with the GIP(t) application is considered to be much more accurate.
Conclusion

The macroeconomics has been considered as an empirical science for many centuries, however, at present time, the macroeconomics is being transformed into the multidisciplinary highly-technical science due to the recent discovery of the Ledenyov digital waves of GDP(t), which constitute a new class of the discrete-time digital signals in the economies of scales and scopes, resulting in an origination of considerable scientific interest by the researchers at the universities, governments and leading central banks toward the creation of new types of the discrete-time digital signals generators for the modeling of the business cycles generation, propagation and its accurate characterization.

In this research article, the authors take a few steps forward and establish their innovative scientific considerations, which are based on a foundational hypothesis that the information is a most important valuable unique product and asset, which is created by the economic agents in the modern information societies in an information age. Then, the authors introduce a notion on the general information product GIP(t) in the macroeconomics, thoughtfully defining the dependence GIP(t) in the frames of the Ledenyov theory on the GIP(t) in the economies of scales and scopes for the first time. The multiple possible origins of the fluctuations of the dependence of the general information product on the time GIP(t) in the economies of scales and scopes are researched comprehensively. Authors consider the GIP(t) as a main parameter, which evaluates the performance of the economies of the scales and scopes from the macroeconomics perspective. Authors assume that the accurate characterization of the dependence GIP(t) can be made in agreement with the Ledenyov theory on GIP(t) in the economies of scales and scopes. Authors believe that the Ledenyov indicator: GIP(t), rather than the Kuznets indicator: GDP(t), can be successfully used to accurately measure the state of any economy of scale and scope in the time domain. Authors think that the GIP(t) is a discrete-time digital signal (the Ledenyov digital wave), but it is not the continuous-time signal (the continuous waves), because of the discrete digital nature of the information generation process by the various economic agents in the modern information societies in an information age.

Finally, the article considers the empirical theoretical approaches and reveals the possible practical technical realizations and limitations in relation to the modeling of the new types of the discrete-time digital signals generators for the Ledenyov digital waves generation in the economies of the scales and scopes in the time and frequency domains.
Complementing the well-established empirical traditions with the new innovative multidisciplinary original research proposals in the macroeconomics, the authors came up to the important conclusion that it is possible to use the general information product $GIP(t)$ instead of both the general domestic product $GDP(t)$ and the general national product $GNP(t)$ with the aim to accurately evaluate the performance of the economies of the scales and scopes at the time of globalization.

Finally, the authors work to estimate the real dependences of the general information product on the time $GIP(t)$ for the G20 economies of the scales and scopes, which are being subtly analyzed and comprehensively discussed presently. These dependences will certainly be described in our next research article in details. The comparative analysis between the $GIP(t)$ and the $GDP(t)$ is also in preparation, but one important thing can be revealed that the characterization method with the $GIP(t)$ is considered to be much more accurate.

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The research on the analog and digital signals processing in the electronics and physics has been conducted by the first author under Prof. Janina E. Mazierska at James Cook University in Townsville in Australia in 2000 – 2015.

The idea to perform the econophysical research on the discrete time digital signals and the continuous-time signals toward the oscillating economic variables spectrum analysis in the macroeconomics attracted the first author’s research interest in recent years.

The first author would like to tell an interesting story that he decided to fly from James Cook University in the City of Townsville in the State of Australia to University of Czernowitz in the City of Czernowitz in the State of Ukraine to pay his respect to Prof. Joseph Alois Schumpeter’s scientific achievements in March, 2015, because Prof. Joseph Alois Schumpeter started to think on the business cycles and economic development in the economics science at University of Czernowitz in the City of Czernowitz in the State of Ukraine in 1909 – 1911, completing the writing of his well known book on the business cycles in Schumpeter (1939).

It may worth to note that the first and second authors were graduated from V. N. Karazin Kharkiv National University in the City of Kharkiv in the State of Ukraine in 1999 and 1993, hence we would like to comment that our research interest in the economic cycles in the economics science is quite natural, because Prof. Simon Kuznets conducted his scientific work on the cyclical fluctuations in the economic systems in the City of Kharkiv in the State of Ukraine in
1915 - 1922, being influenced by the Prof. Joseph Alois Schumpeter research ideas and coming up with the remarkable research results in Kuznets (1930, 1973).

It is a notable historical fact that the first and second authors were strongly influenced by the remarkable scientific papers and books by Lev Davydovich Landau, who had a considerable interest in the physics and, at the later stage of his life, in the econophysics, working in the City of Kharkiv in the State of Ukraine in 1930s.

The second author began his research work on the information processing, specifically focusing on the information processing and coding by various electronic computing devices in Ukraine in the later 1980s and early 1990s. The second author made his significant research contributions to establish the scientific field on the information processing by the quantum computing devices, researching and developing the 1024 Quantum Random Number Generator on the Magnetic Flux Qubits, based on the Superconducting Quantum Interference Device (SQUID) arrays, for the space applications at a number of leading research institutions and elite universities in Europe and in North America since mid 1990s. The second author is frequently regarded and commonly recognized as a founder of the research field on the information processing by the superconducting quantum computing devices, which was established in Europe almost 30 years ago.

Discussing the scientific problems on the signal generation, it is necessary to comment that the second author completed his research on the Gunn diode microwave generators in 1991-1992 at V. N. Karazin Kharkiv National University in Kharkiv, Ukraine, and then continued his innovative scientific work on the various scientific programs towards the continuous-time waves generators such as the Yttrium Iron Garnet (YIG) microwave generators, tuned by the magnetic field, as well as the discrete-time digital signal generators such as the 1024 Quantum Random Number Generator on the Magnetic Flux Qubits, based on the Superconducting Quantum Interference Device (SQUID) arrays, during the last three decades. In addition, the second author has developed a plenty of experience in the discrete-time digital signal generators, using the digital modulation techniques such as the Pulse Amplitude Modulation (PAM), Qudrature Amplitude Modulation (QAM), Phase Shift Keying (BPSK, QPSK, MPSK), Frequency Shift Keying (FSK), Gaussian Minimum Shift Keying (GMSK), etc.

Let us repeat that this innovative research uses the knowledge on the analogue and digital signals processing in the physics and the electronics engineering, which is described in our book on the nonlinearities in the microwave superconductivity in Ledenyov D O, Ledenyov V O (2015a).
The final writing, editing and reading of our research article have been made by the authors during our travel to the Prof. Viktor Yakovlevich Bunyakovsky motherland in the Town of Bar in Vinnytsia Region in the State of Ukraine in the beginning of May, 2015. The additional research changes have been introduced by the authors at the City of Kharkiv in the State of Ukraine in the beginning of June, 2015.

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          ledenyov@univer.kharkov.ua .

References:

**Economics Science, Finance Science, Economic History Science:**

4. Menger C 1871 Principles of Economics (Grundsätze der Volkswirtschaftslehre) Ludwig von Mises Institute Auburn Alabama USA
5. Bagehot W 1873, 1897 Lombard Street: A description of the money market *Charles Scribner's Sons* New York USA.
6. von Böhm-Bawerk E 1884, 1889, 1921 Capital and interest: History and critique of interest theories, positive theory of capital, further essays on capital and interest Austria; 1890 *Macmillan and Co* Smart W A (translator) London UK
10. Schumpeter J A 1933 The common sense of econometrics *Econometrica.*


15. Slutsky E E 1915 Sulla teoria del bilancio del consumatore Giornale degli economisti e rivista di statistica 51 no 1 pp 1 – 26 Italy.


22. Ellis H, Metzler L (editors) 1949 Readings in the theory of international trade Blakiston Philadelphia USA.

23. Friedman M (editor) 1953 Essays in positive economics Chicago University Press Chicago USA.


**Juglar Economic Cycle:**


**Kondratiev Economic Cycle:**

36. Kondratieff N D 1922 The world economy and its trends during and after war Regional branch of state publishing house Vologda Russian Federation.

37. Kondratieff N D 1925 The big cycles of conjuncture The problems of conjuncture 1 (1) pp 28 – 79.


41. Kondratieff N D 1984 The Long wave cycle Richardson & Snyder New York USA.


52. Van Duijn J J 1979 The long wave in economic life *De Economist* 125 (4) pp 544 – 576.


54. Van Duijn J J 1983 The long wave in economic life *Allen and Unwin* Boston MA USA.


58. Tinbergen J 1981 Kondratiev cycles and so-called long waves: The early research *Futures* 13 (4) pp 258 – 263.
63. Wallerstein I 1984 Economic cycles and socialist policies *Futures* 16 (6) pp 579 – 585.
67. Freeman C, Louçã F 2001 As time goes by: From the industrial revolutions to the information revolution *Oxford University Press* Oxford UK.
68. Goldstein J 1988 Long cycles: Prosperity and war in the modern age *Yale University Press* New Haven CT USA.
70. Berry B J L 1991 Long wave rhythms in economic development and political behavior *Johns Hopkins University Press* Baltimore MD USA.
74. Tylecote A 1992 The long wave in the world economy Routledge London UK.
79. Perez C 2002 Technological revolutions and financial capital – The dynamics of bubbles and golden ages Edward Elgar Cheltenhem UK.
87. Wikipedia 2015a Kondratieff Wikipedia USA

**Kitchin Economic Cycle:**


**Kuznets Economic Cycle:**

89. Kuznets S 1924 Economic system of Dr. Schumpeter *M. Sc. Thesis under Prof. Wesley Clair Mitchell* Columbia University NY USA.

90. Kuznets S 1930 Secular movements in production and prices *Ph. D. Thesis under Prof. Wesley Clair Mitchell* Columbia University NY USA.

91. Kuznets S 1930 Secular movements in production and prices. Their nature and their bearing upon cyclical fluctuations *Houghton Mifflin* Boston USA.


96. Kuznets S 1966 Modern economic growth: Rate, structure, and spread.

97. Kuznets S 1968 Toward a theory of economic growth, with reflections on the economic growth of modern nations.

98. Kuznets S 1971 Economic growth of nations: Total output and production structure.


106. Street J H June 1988 The contribution of Simon S. Kuznets to institutionalist
development theory *Journal Economic Issues* vol 22 no 2 pp 499 – 509.


**Accurate Characterization of Properties of Economic Cycles:**


117. Samuelson P A 1947 Foundations of economic analysis *Harvard University Press* Cambridge MA USA.

118. Hicks J R 1950 A contribution to the theory of the trade cycle *Oxford University Press* Oxford UK.


137. Sussmuth B 2003 Business cycles in the contemporary World *Springer* Berlin Heidelberg Germany.
Edward Elgar Cheltenham UK Northampton MA USA.


143. Jourdon Ph 2008 La monnaie unique europeenne et son lien au developpement economique et social coordonne: une analyse cliometrique Thèse Universite Montpellier France.


157. Desai M, King St, Goodhart Ch 2015 Hubris: why economists failed to predict the crisis and how to avoid the next one Public Lecture on 27.05.2015 London School of Economics and Political Science London UK http://media.rawvoice.com/lse_publiclecturesandevents/richmedia.lse.ac.uk/publiclecturesandevents/20150527_1830_hubris.mp4.


**Disruptive Innovation in Terms of Economics Science:**

159. Schumpeter J A 1911; 1939, 1961 Theorie der wirtschaftlichen entwicklung; The theory of economic development: An inquiry into profits, capital, credit, interest and the business cycle Redvers Opie (translator) OUP New York USA.


175. Christensen C M April 1999c Teradyne: The Aurora project & Teradyne: Corporate management of disruptive change, TN *Harvard Business School Teaching Note* 399 - 087.


178. Christensen C M 1999a Innovation and the general manager Irwin McGraw-Hill Homewood IL USA.

179. Christensen C M 1999b Impact of disruptive technologies in telecommunications in Bringing PC economies to the telecommunications industry PulsePoint Communications.


196. Shah Ch D, Brennan T A, Christensen C M April 2003 Interventional radiology: Disrupting invasive medicine.

197. Christensen C M March April 2003 Beyond the innovator's dilemma *Strategy & Innovation* 1 no 1.


208. Dyer J H, Gregersen H B, Christensen C M 2011 The innovator's DNA: Mastering the five skills of disruptive innovators *Harvard Business Press* Boston MA USA.


214. Bernoulli J 1713 Ars conjectandi (The art of guessing).


216. De Moivre 1730 Miscellanea analytica supplementum (The analytic method).


220. Bunyakovsky V Ya 1825 Rotary motion in a resistant medium of a set of plates of constant thickness and defined contour around an axis inclined with respect to the horizon Ph D Thesis no 1 under Prof. Augustin - Louis Cauchy supervision École Polytechnique Paris France.


223. Bunyakovsky V Ya 1846 Foundations of the mathematical theory of probability
St. Petersburg Russian Federation.

224. Connor J J, Robertson E F (July) 2000 Viktor Yakovlevich Bunyakovsky (December 16, 1804 - December 12, 1889) School of Mathematics and Statistics University of St Andrews Scotland UK
http://www-history.mcs.st-andrews.ac.uk/Biographies/Bunyakovsky.html .

225. V Ya Bunyakovsky International Conference (August 20 - 21) 2004 Private communications with conference participants on V Ya Bunyakovsky’s mathematical theory of probability and its applications in econophysics and econometrics during a tour to Town of Bar Vinnytsia Region Ukraine V Ya Bunyakovsky International Conference Institute of Mathematics of National Academy of Sciences of Ukraine (NASU) Kyiv Ukraine
www.imath.kiev.ua/~syta/bunyak .

226. Chebyshev P L 1846 An experience in the elementary analysis of the probability theory
Crelle’s Journal für die Reine und Angewandte Mathematik.


229. Chebyshev P L 1936 Theory of probability: Lectures given in 1879 and 1880
Lyapunov A N (lecture notes writer) Krylov A N (editor) Moscow - St Petersburg Russian Federation.


246. Slutsky E E 1913 On the criterion of goodness of fit of the regression lines and the best method of fitting them to the data *Journal Royal Statistics Society* vol 77 part I pp 8 – 84.

248. Slutsky E E 1915 Sulla teoria sel bilancio del consumatore Giornale degli economisti e rivista di statistica 51 no 1 pp 1 – 26 Italy.


255. Slutsky E E 1925b Ueber stochastische Asymptoten und Grenzwerte Metron Padova Italy vol 5 no 3 pp 3 – 89.


257. Slutsky E E 1927a The summation of random causes as sources of cyclic processes Problems of Conjuncture (Voprosy Kon'yunktury) vol 3 issue 1 pp 34 – 64 Moscow Russian Federation.


262. Slutsky E E 1937b The summation of random causes as the source of cyclical processes Econometrica 5 pp 105 – 146.
266. Kolmogorov A N 1937 Markov chains with countable many states Bulletin Moscow University 1.
268. Kolmogorov A N 1947 The contribution of Russian science to the development of probability theory Uchenye Zapiski Moskovskogo Universiteta no 91.


298. Mandelbrot B B 1977 Fractals: Form, chance and dimension W H Freeman San Francisco USA.

299. Mandelbrot B B 1982 The fractal geometry of nature W H Freeman San Francisco USA.

300. Mandelbrot B B 1997 Fractals and scaling in finance Springer New York USA.

301. Gnedenko B V, Khinchin A Ya 1961 An elementary introduction to the theory of probability Freeman San Francisco USA.


308. Shiryaev A N 1967 Two problems of sequential analysis Cybernetics 3 pp 63 – 69.


343. Lamperti J 1966 Probability *Benjamin* New York USA.


349. Breiman L 1968 Probability *Addison-Wesley* Reading MA USA.


368. Maddala G S 1983 Limited-dependent and qualitative variables in econometrics *Cambridge University Press* Cambridge UK.
377. Taylor S 1986 Modeling financial time series John Willey and Sons Inc New York USA.
389. Cleveland W S 1993 Visualizing data Hobart Press Summit New Jersey USA.
390. Pesaran M H, Potter S M (editors) 1993 Nonlinear dynamics, chaos and econometrics John Willey and Sons Inc New York USA.


397. Moore G E 2003 No exponential is forever – but we can delay forever. *ISSCC*.


415. Hayashi F 2000 Econometrics *Princeton University Press* Princeton NJ USA.


Selected Research Papers in Macroeconomics, Microeconomics & Nanoeconomics Sciences:


444. Ledenyov D O, Ledenyov V O 2013e To the problem of evaluation of market risk of global equity index portfolio in global capital markets MPRA Paper no 47708 Munich University Munich Germany pp 1 – 25
   http://mpra.ub.uni-muenchen.de/47708/.

   http://mpra.ub.uni-muenchen.de/49964/.

   http://mpra.ub.uni-muenchen.de/50235/,


452. Ledenyov D O, Ledenyov V O 2014d On the fundamentals of winning virtuous strategies creation toward leveraged buyout transactions implementation during private equity investment in conditions of resonant absorption of discrete information in diffusion - type financial system with induced nonlinearities MPRA Paper no 61805 Munich University

Ledenyov D O, Ledenyov V O 2014f MicroLBO software program with the embedded optimized near-real-time artificial intelligence algorithm to create winning virtuous strategies toward leveraged buyout transactions implementation and to compute direct/reverse leverage buyout transaction default probability number for selected public/private companies during private equity investment in conditions of resonant absorption of discrete information in diffusion - type financial system with induced nonlinearities ECE James Cook University Townsville Australia, Kharkov Ukraine.


460. Ledenyov D O, Ledenyov V O 2015f *MicroID* software program with the embedded optimized near-real-time artificial intelligence algorithm to create the winning virtuous business strategies and to predict the director’s election / appointment in the boards of directors in the firms, taking to the consideration both the director’s technical characteristics and the interconnecting interlocking director’s network parameters in conditions of the resonant absorption of discrete information in diffusion - type financial economic system with induced nonlinearities ECE James Cook University Townsville Australia, Kharkov Ukraine.

461. Ledenyov D O, Ledenyov V O 2015g *MicroITF* operation system and software programs: 1) the operation system to control the firm operation by means of the information resources near-real-time processing in the modern firms in the case of the diffusion - type financial economic system with the induced nonlinearities; 2) the software program to accurately characterize the director’s performance by means of a) the filtering of the generated/transmitted/received information by the director into the separate virtual channels, depending on the information content, and b) the measurement of the levels of signals in every virtual channel with the generated/transmitted/received information by the director, in the overlapping interconnecting interlocking directors networks in the boards of directors in the firms during the Quality of Service (QoS) measurements process; and 3) the software program to create the winning virtuous business strategies by the interlocking interconnecting directors in the boards of directors in the modern firms in the case of the diffusion - type financial economic system with the induced nonlinearities, using the patented recursive artificial intelligence algorithm ECE James Cook University Townsville Australia, Kharkov Ukraine.

46
462. Ledenyov D O, Ledenyov V O 2015h MicroIMF software program: the MicroIMF software program to make the computer modeling of 1) the interactions between the information money fields of one cyclic oscillation and the information money fields of other cyclic oscillation(s) in the nonlinear dynamic economic system, 2) the interactions between the information money fields of cyclic oscillation and the nonlinear dynamic economic system itself, and 3) the density distributions of the information money fields by different cyclic oscillations (the economic continuous waves) in the nonlinear dynamic economic system ECE James Cook University Townsville Australia, Kharkov Ukraine.

463. Ledenyov D O, Ledenyov V O 2015i MicroSA software program 1) to perform the spectrum analysis of the cyclic oscillations of the economic variables in the nonlinear dynamic economic system, including the discrete-time signals and the continuous-time signals; 2) to make the computer modeling and to forecast the business cycles for a) the central banks with the purpose to make the strategic decisions on the monetary policies, financial stability policies, and b) the commercial/investment banks with the aim to make the business decisions on the minimum capital allocation, countercyclical capital buffer creation, and capital investments ECE James Cook University Townsville Australia, Kharkov Ukraine.

Continuous Time Signal, Analog Signals, Discrete Time Signal, Digital Signals, Spectrum of Signals, Electromagnetic Field, Gravitation Field, Calibrating Field, Information Field

Theories in Physics and Engineering Sciences:


466. Walsh J L 1923b A property of Haar’s system of orthogonal functions Math Ann 90 p 3845.


47
470. Bose R C, Shrikhande S S 1959 A note on a result in the theory of code construction
Information and Control 2 (2) pp 183 – 194 doi:10.1016/S0019-9958(59)90376-6
CiteSeerX: 10.1.1.154.2879
http://dx.doi.org/10.1016%2FS0019-9958%2859%2990376-6

University Press Princeton USA.

472. Yuen C-K 1972 Remarks on the ordering of Walsh functions IEEE Transactions on
Computers 21 (12) p 1452 doi:10.1109/T-C.1972.223524
http://dx.doi.org/10.1109%2FT-C.1972.223524 .

New York USA.

New York USA.

USA.

476. Anceau F 1986 The architectures of microprocessors Addison-Wesley Wokingham
England.

UK.


Englewood Cliffs NJ USA.

Englewood Cliffs NJ USA.

481. Van de Goor A J 1989 Computer architecture and design Addison-Wesley Wokingham
England.

482. Priemer R 1991 Introductory signal processing World Scientific Singapore

Upper Saddle River NJ USA, 2nd edition Noble Pub Corp Atlanta GA USA