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Wave function method to forecast foreign currencies exchange rates at ultra high frequency electronic trading in foreign currencies exchange markets

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Abstract – The accurate forecast of the foreign currencies exchange rates at the ultra high frequency electronic trading in the foreign currencies exchange markets is a main topic of our research: **1)** the present state of the foreign currencies exchange markets in Asia, Europe and North America; **2)** the research review on the classic forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets in the classic finances theory; **3)** the description on the quantum forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets with the application of both the wave function and the time dependent / time independent wave equation in the quantum finances theory; **4)** the derivation of the time dependent / time independent wave equation in the quantum finances theory; **5)** the creation of the quantum system state prediction algorithm, based on both the wave function and the time dependent / time independent wave equation in the quantum finances theory; **6)** the discussion on the developed software program with the embedded quantum system state prediction algorithm, using both the wave function and the time dependent / time independent wave equation in the quantum finances theory; **7)** the final words on the perspectives of the quantum forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets, applying both the wave function and the time dependent / time independent wave equation in the quantum finances theory.

JEL: G1, G10, G12, G14, G15, G20, C40, C42, C82, D0, D82, E42, F3, F4, F31

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Keywords: ultra high frequency electronic trading, foreign currencies exchange rates, foreign currencies exchange markets, vehicle currency, interest rate, retail aggregator, liquidity aggregator, interdealer trade orders flow direction, stop-loss order, bid - ask spreads, price discovery process, capital inflow, capital outflow, carry trade strategy, financial liquidity, FX market micro structure, FX rate dynamics, absorption/diffusion/transmission of information, information theory, asymmetric information, autoregressive conditional heteroskedasticity, Wiener filtering theory, Stratanovich-Kalman-Bucy filtering algorithm / filter, particle filter, quantum system state prediction algorithm with wave function, time dependent / time independent wave equation, nonlinearities, artificial intelligence, Ledenyov strategy search algorithm, econophysics, econometrics, global foreign exchange market, global capital market, wealth management.

Introduction

*The ultra high frequency electronic trading is a trading process between the participating traders to trade the foreign currencies in the foreign currencies exchange markets at the time period of 10^{-9} sec. The ultra high frequency electronic trading takes an advantage of the fact that the foreign currencies exchange rates change at the ultra high frequencies due to the high performance computing application, resulting in the new opportunities for the traders to make the profitable trade deals completion at the foreign currencies exchange markets. The scientific term such as the **ultra high frequency electronic trading** has been recently introduced in Ledenyov D O, Ledenyov V O (2014c) and the scientific term such as the **high frequency electronic trading** has been introduced some time ago in Goodhart, Hall, Henry, Pesaran (1993), Goodhart, O'Hara (1995), Goodhart, O'Hara (1997).*

Discussing the *technical realization aspects* of the *ultra high frequency electronic trading process*, it makes sense to explain that the *ultra high frequency electronic trading* is usually realized with the use of the *complex algorithms*, which are implemented in the *object oriented and sequential software*, compiled by the *compilers* into the *executable file*, and executed by the *operating system* at the *high performance computing hardware*.

There are *many various economic/financial/technical factors*, which may have certain impacts on the *change dynamics* of the *foreign currencies exchange rates* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*. For instance, it is a well known fact that the *foreign currencies exchange rates* in the *foreign currencies exchange markets* fluctuate at the *ultra high frequencies* in the *frequency domain*, depending on:

1. The *foreign currencies supply and demand* in the *process of the foreign currencies trading* at the *in the foreign currencies exchange markets* at the *given time moment*.
2. The *propagation properties of the discrete-time digital waves* (the *business cycles*) in the *economies of the scales and scopes* in the *time domain* at the *Schumpeterian creative disruption age*;
3. The *technical parameters of the algorithms*, used by the *traders* in the *process of the foreign currencies trading* at the *in the foreign currencies exchange markets*;
4. The *technical specifications of the computers*, used by the *traders* in the *process of the foreign currencies trading* at the *in the foreign currencies exchange markets*;
5. The *volumes of the foreign currencies*, traded at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*;

6. The *frequencies of the trade deals completion at the ultra high frequency electronic trading in the foreign currencies exchange markets;*
7. The *characteristics of the traders' discrete-time information absorption processes in the diffusion - type financial systems with the induced nonlinearities;*
8. *Some other parameters.*

From the *wealth management point of view, the investment of the money, professional efforts and working time in the ultra high frequency electronic trading in the foreign currencies exchange markets is a best way to increase and accumulate the enormous private/institutional wealth by the experienced investors on a global scale at the present time of the disruptive changes.* In addition, the *authors' scientific opinion* reflects their view on the subject that an *increasing application of the electronic computing technologies in the finances opens a big number of unbounded lucrative business opportunities towards the high profitable trading deals completion in an era of the ultra high frequency electronic trading in the foreign currencies exchange markets at the time of globalization.*

Having said that, we would like to emphasize that the *following research topics* are comprehensively discussed in this *research article*:

1. The *present state of the foreign currencies exchange markets in Asia, Europe and North America;*
2. The *research review on the classic forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets in the classic finances theory;*
3. The *description on the quantum forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets with the application of both the wave function and the time dependent / time independent wave equation in the quantum finances theory;*
4. The *derivation of the time dependent / time independent wave equation in the quantum finances theory;*
5. The *creation of the quantum system state prediction algorithm, based on both the wave function and the time dependent / time independent wave equation in the quantum finances theory;*
6. The *discussion on the developed software program with the embedded quantum system state prediction algorithm, using both the wave function and the time dependent / time independent wave equation in the quantum finances theory;*

7. The final words on the perspectives of the quantum forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets, applying the time dependent / time independent wave equation with wave function in the quantum finances theory.

Literature review on high frequency electronic trading in foreign currencies exchange markets

Researching the subject of interest on the high frequency electronic trading in the foreign currencies exchange markets in Ledenyov D O, Ledenyov V O (2014c), the authors analyzed a wide range of existing scientific problems, identified a number of significant scientific contributions and made a comprehensive literature review. Let us list the research works by the brilliant scientists, who contributed to the field of research on the foreign currencies exchange rates dynamics in the foreign currencies exchange markets in Ellis, Metzler (editors) (1949), Machlup (1949), Robinson (1949), Friedman (1953), Baumol (1957), Debreu (1959), Fama (1965, 1970, 1984, 1998), Fama, Blume (1966), Fama, French (1988, 1996), Fama, Hansen, Shiller (2013), Demsetz (1968), Radner (1968), Bates, Granger (1969), Akerlof (1970), Arrow (1970), Black (1971, 1986), Black, Scholes (1973), Merton (1973), Newbold, Granger (1974), Fleming (1975), Shapiro (1975), Dooley, Shafer (1976), Dornbusch (1976, 1987), Frankel (1976, 1979, 1982a, b, 1983, 1992, (editor) 1993), Frankel, Froot (1987, 1990a, b, c), Frankel, Goldstein, Mason (1991), Frankel, Rose (1994, 1995), Frankel, Galli, Giovannini (editors) (1996), Frankel, Poonawala (2004), Garman (1976), Grossman (1976), Grossman, Stiglitz (1980), Grossman, Miller (1988), Kouri (1976), McKinnon (1976), Mussa (1976, 1979, 1981, 1984), Williamson (1976), Branson (1977), Branson, Halttunen, Masson (1977), Branson, Henderson (1985), Clark, Logue, Sweeney (editors) (1977), Girton, Henderson (1977), Cornell, Dietrich (1978), Cornell (1982), Stoll (1978, 1985, 1989, 1995, 1998, 2006), Huang, Stoll (1996, 1997), Stoll, Schenzler (2005), Blanchard (1979), Brunner, Meltzer (editors) (1979), Deardorff (1979), Goodman (1979), Aliber (1980, 2002), Allen, Kenen (1980), Amihud, Mendelson (1980), Amihud, Ho, Schwartz (editors) (1985), Amihud (1994a, b, c) Amihud, Levich (editors) (1994), Hansen, Hodrick (1980), Hellwig (1980, 1982), Krugman (1980, 1984, 1991, 1999), Krugman, Miller (1993), Callier (1981), Cohen, Maier, Schwartz, Whitcomb (1981), Cox, Ingersoll, Ross (1981), Diamond, Verrecchia (1981), Diamond (1982), Fieleke (1981), Ho, Stoll (1981, 1983), Loosignian (1981), Stigum (1981, 1990), Dooley, Isard (1982), Hansen (1982), Hodder (1982), Milgrom, Stokey (1982), Taylor D (1982), Bigman, Taya (editors) (1983), Copeland, Galai

(1983), Dooley, Shafer (1983), Edwards (1983), French (1983), Garman, Kohlhagen (1983), Meese, Rogoff (1983a, b, 1988) Rogoff (1984, 1985, 1996), Meese (1986, 1990), Obstfeld, Rogoff (1995, 1998), Robinson (1983), Adler, Dumas (1984), Backus (1984), Bilson, Marston (editors) (1984), Booth (1984), Engel, Frankel (1984a, b), Engel, Hamilton (1990), Engel (1992, 1995, 1996, 1999), Devereux, Engel (1999, 2002), Devereux, Shi (2005), Engel, West (2004a, b, 2005, 2006), Engel, Mark, West (2007), Garner, Shapiro (1984), Loopesko (1984), Roll (1984), French, Roll (1986), Roll (1988), White, Domowitz (1984), Bahmani-Oskooee, Das (1985), Cohen, Conroy, Maier (1985), Glosten, Milgrom (1985), Glosten, Harris (1988), Glosten (1989, 1994), Hakkio, Pearce (1985), Hardouvelis (1985), Jones, Kenen (editors) (1985), Kearney, Macdonald (1985), Kyle (1985, 1989), Kyle, Xiong (2001), Levich (1985), McNish, Wood (1985), Dominguez (1986, 1990, 1992, 1993, 1998, 2003a, b), Dominguez, Frankel (1993a, b, c), Bollerslev (1986, 1990), Baillie, Bollerslev (1989, 1990, 1991), Bollerslev, Chou, Jayaraman, Kroner (1990), Bollerslev, Domowitz (1991, 1993), Bollerslev, Melvin (1994), Andersen, Bollerslev (1994, 1998), Bollerslev, Engle, Nelson (1995), Bollerslev, Cai, Song (2000), Andersen, Bollerslev, Diebold, Labys (2000, 2001, 2003), Andersen, Bollerslev, Diebold, Vega (2001, 2003), Andersen, Bollerslev, Diebold (2007), Engle (1982) Engle, Bollerslev (1986), Engle, Granger (1987), Engle, Rodriguez (1989), Engle, Ito, Lin Wen-Ling (1990), Engle, Russell (1995), Engle, Gallo (2006), Evans (1986), Flood, Lessard (1986), Grammatikos, Saunders, Swary (1986), Harris (1986, 1990), Hart, Kreps (1986), Lyons (1986, 1988, 1990, 1991, 1992, 1993a, b, c, 1994, 1995, 1996a, b, 1997a, b, c, 1998a, b, 2001, 2002a, b, 2003, 2006), Baldwin, Lyons (1994), Lyons, Rose (1995), Fan, Lyons (2001, 2003), Killeen, Lyons, Moore (2001), Killeen, Hau, Moore (2001), Killeen, Lyons, Moore (2006), O'Hara, Oldfield (1986), Burdett, O'Hara (1987), O'Hara (1995, 1998), Shleifer (1986), Shleifer, Summers (1990), Sweeney (1986), DeLong, Shleifer, Summers, Waldmann (1990), Bilson, Hsieh (1987), Glassman (1987), Gerlach (1987), Hasbrouck, Ho (1987), Hasbrouck (1988, 1991), Hasbrouck, Sofianos (1993), Hasbrouck, Seppi (2001), Hodrick (1987), Ito, Roley (1987, 1990), Canova, Ito (1991), Ito, Engle, Lin (1992), Ito, Lin (1992), Ito, Isard, Symansky, Bayoumi (1996), Ito, Lyons, Melvin (1998), Ito (2002, 2005a, b), Ito, Hashimoto (2006), Mendelson (1987), Newey, West (1987), Rubinstein, Wolinsky (1987), Taylor (1987, 1989, 1995, 2005), Allen, Taylor (1989), Taylor, Allen (1992), Sarno, Taylor (2000, 2001a, b), Sager, Taylor (2005, 2006, 2008), Reitz, Taylor (2006), Schulmeister (1987), Melvin, Taylor (2009), Newey, West (1987), Wolff (1987), Admati, Pfleiderer (1988, 1989), Boothe (1988), Choi, Salandro, Shastri, Clinton (1988), Goodhart (1988, 1989, 1992), Goodhart, Demos (1990, 1991a, b), Goodhart, Curcio (1991), Goodhart, Figliuoli (1991), Goodhart, Hall, Henry, Pesaran (1993), Goodhart, Hesse (1993),

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Wave function to forecast foreign currencies exchange rates at ultra high frequency electronic trading in foreign currencies exchange markets

During the process of the *foreign currencies exchange rates forecast* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*, the **computing modeling result accuracy** depends on such factors as:

1. The *mathematical model meaningfulness and validity*;
2. The *quality of the random number generator*; and
3. The *technical parameters of the high performance computing system*.

Therefore, a *considerable research attention* is paid to the development of the **meaningful mathematical model**, which must account for all the *financial variables changes* in the *time, frequency and space domains* as well as have to apply all the theories on the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*.

Going to the thoughtful discussion on the technical issues, let us remind that the *foreign currencies forward exchange rate* is a sum of the two components: a *foreign currencies future spot rate* and a *time-varying risk premium* in Yu, Fung, Hongyi (2005), Ledenyov D O, Ledenyov V O (2014c):

$$\text{Foreign Currencies Forward Exchange Rate} = \text{Foreign Currencies Spot Exchange Rate} + \text{Time Varying Risk Premium}$$

Discussing the *mathematical models*, we would like to say that the *existing research approaches* to forecast the *foreign currencies exchange rates* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets* include, but not limited to, the following well known *financial analysis methods and models* in the *classic finances science* in Ledenyov D O, Ledenyov V O (2014c):

1. **Macroeconomic analysis methods**, based on:
 - 1) The *Purchasing Power Parity* model;
 - 2) The *Uncovered Interest Rate Parity* model;
 - 3) The *Sticky Price Monetary* model;
 - 4) The *Bayesian Averaging Technique* model;
 - 5) The *Combined Forecast* model.
2. **Microeconomic analysis methods**, based on:
 - 1) The *market microstructure model*;
 - 2) The *transactions order flow model*;
 - 3) The *generalized autoregressive conditional heteroskedasticity model*;
 - 4) The *Stratanovich-Kalman-Bucy filtering algorithm model*;
 - 5) The *particle filtering algorithm model*.

However, the *national/global financial systems of scale and scope* can be described as the *discrete-time quantum systems* rather than the *continuous-time systems*, because of their *discrete-time quantum nature* in view of the *disruptive events influences* in Ledenyov D O, Ledenyov V O (2015h, i, j, k). Therefore, the **quantum finances science** instead of the *classic finances science* has to be used with the aim to accurately characterize the *foreign currencies exchange rates dynamics* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*. In other words, all the above listed research approaches, aiming to predict the *foreign currencies exchange rates* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*, have a *limited accuracy*, because they can characterize the *relatively slow changing continuous-time signals* only, but not the *discrete-time digital signals*.

Applying the *quantum macroeconomic theory* in Ledenyov D O, Ledenyov V O (2015h) and the *quantum microeconomic theory* in Ledenyov D O, Ledenyov V O (2015j), the authors propose a *new research methodology* to forecast the *foreign currencies exchange rates* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*, which include the following newly invented innovative *financial analysis methods and models* in the *quantum finances science*:

1. **Macroeconomic analysis method**, based on:

1) The *Ledenyov wave function* in the *time dependent Ledenyov quantum econophysical wave equation model*;

2) The *Ledenyov wave function* in the *time independent Ledenyov quantum econophysical wave equation model*.

2. **Microeconomic analysis methods**, based on:

1) The *Ledenyov wave function* in the *time dependent Ledenyov quantum econophysical wave equation model*;

2) The *Ledenyov wave function* in the *time independent Ledenyov quantum econophysical wave equation model*.

The **time dependent Ledenyov quantum econophysical wave equation** in the *wave function method to forecast the foreign currencies exchange rates at the ultra high frequency electronic trading in the foreign currencies exchange markets* can be written as

$$i\lambda_{FX} \frac{\partial}{\partial t} w_{FX} = \hat{L}_{FX} w_{FX}, \quad (1)$$

where: i – the *imaginary unit*,

w_{FX} – the *wave function of a quantum financial system, which is a mathematical function in the quantum mechanics to accurately characterize a specified state of a quantum financial system. The square of the amplitude of the wave function at a given point being representative of the probability of the system being found in that state at that point.*

λ_{FX} – the *Ledenyov constant*,

t – the *time*,

$\frac{\partial}{\partial t}$ – the *partial derivative with respect to the time*,

\hat{L}_{FX} – the *Ledenyov operator to characterize the total energy of the wave function*.

The **time independent Ledenyov quantum econophysical wave equation** in the *wave function method to forecast the foreign currencies exchange rates at the ultra high frequency electronic trading in the foreign currencies exchange markets* can be written as

$$E_{FX} w_{FX} = \hat{L}_{FX} w_{FX}, \quad (2)$$

where: w_{FX} – the *wave function of a quantum financial system, which is a mathematical function in the quantum mechanics to accurately characterize a specified state of a quantum financial system. The square of the amplitude of the wave function at a given point being representative of the probability of the system being found in that state at that point*,

\hat{L}_{FX} – the *Ledenyov operator to characterize the total energy of the wave function*,

E_{FX} – the energy of the state w_{FX} .

It is necessary to add that we developed a *software program*, which uses the *quantum system state prediction algorithm*, based on the *time dependent / time independent wave equation* with the *wave function* in the *quantum finances theory*, to forecast the *foreign currencies exchange rates* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets*.

In addition, we successfully applied the *software program*, which uses the *quantum system state prediction algorithm*, based on the *time dependent / time independent wave equation* with the *wave function* in the *quantum finances theory*, with the aim to forecast the *foreign currencies exchange rates* at the *ultra high frequency electronic trading* in the *global foreign currencies exchange markets*.

This *innovative research* on the *foreign currencies exchange rates* at the *ultra high frequency electronic trading* in the *foreign currencies exchange markets* is done, using the *following scientific literature*:

1. The ***econophysics science*** in Schumpeter (1906, 1933), Bowley (1924), Box, Jenkins (1970), Grangel, Newbold (1977), Van Horne (1984), Taylor S (1986), Tong (1986, 1990), Judge, Hill, Griffiths, Lee, Lutkepohl (1988), Hardle (1990), Grangel, Teräsvirta (1993), Pesaran, Potter (1993), Banerjee, Dolado, Galbraith, Hendry (1993), Hamilton (1994), Karatzas, Shreve (1995), Campbell, Lo, MacKinlay (1997), Rogers, Talay (1997), Hayashi (2000), Durbin, Koopman (2000, 2002, 2012), Ilinski (2001), Greene (2003), Koop (2003), Davidson, MacKinnon (2004), Campbell, Lo, MacKinlay (1996).

2. The ***quantum mechanics science*** in Planck (1900a, b, c, d, 1901, 1903, 1906, 1914, 1915, 1943), Einstein (1905, 1917, 1924, 1935), Einstein, Podolsky, Rosen (1935), Bohr (1922, 1924), de Broglie L (1924, 1925, 1926, 1927, 1928), Compton (1926), Compton A, Allison S K (1935), Schrödinger (1926), Schiff (1949), Akhiezer, Berestetsky (1953, 1964, 1980), Berestetsky, Lifshits, Pitaevsky (1980), Dirac (1958), Merzbacher (1961), Feynman, Leighton, Sands (1965), Atkins (1974, 1977, 1978), Landau, Lifshits (1977), Bransden, Joachain (1983), Resnick, Eisberg (1985), Galindo, Pascual (1990, 1991), Shankar (1994), Ballentine (1998), Bransden, Joachain (2000), Liboff (2002), Abers, Pearson (2004), Blokhintsev (2004), Griffiths (2004), Vakarchuk (2004), McMahan (2006), Halliday (2007), Hand, Finch (2008), Teschl (2009), Zettili (2009), Laloe (2012), Rylov (2015);

3. The ***probability science*** in De Laplace (1812), Bunyakovsky (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).

Conclusion

This research article presents an original research on the following scientific topics:

- 1) the present state of the foreign currencies exchange markets in Asia, Europe and North America;
- 2) the research review on the classic forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets in the classic finances theory;
- 3) the description on the quantum forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets with the application of the time dependent / time independent wave equation with the wave function in the quantum finances theory;
- 4) the derivation of the time dependent / time independent wave equation in the quantum finances theory;
- 5) the creation of the quantum system state prediction algorithm, based on both the wave function and the time dependent / time independent wave equation in the quantum finances theory;
- 6) the discussion on the developed software program with the embedded quantum system state prediction algorithm, using both the wave function and the time dependent / time independent wave equation in the quantum finances theory;
- 7) the final words on the perspectives of the quantum forecast techniques of the foreign currencies exchange rates dynamics in the foreign currencies exchange markets, applying the time dependent / time independent wave equation with the wave function in the quantum finances theory.

Acknowledgement

The first author started his scientific work on the information processing in Kharkiv, Ukraine, researching the microwave filters, making the discovery that the quantum knot of the magnetic vortex is in an extreme quantum limit, focusing on the research and development toward the ultra dense memory on the quantum knots of the magnetic vortices, and presenting his innovative research results at the international conferences, including the Marconi seminar at Birmingham University in the UK in 1999.

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

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 be interesting 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*. The *V. N. Karazin Kharkiv National University*, was founded in *1805* in *Kharkiv, Ukraine*, becoming a leading high educational institution in *Europe in IXX-XXI centuries*. Let us remind that *Prof. Tugan-Baranovsky*, who originated the *business cycle research*, was graduated with his *first technical degree* from *V. N. Karazin Kharkiv National University* in *Kharkiv, Ukraine* at the end of *IXX century*. *Prof. Nikolai D. Kondratiev*, who is well known for his groundbreaking *research on the business cycles*, considered *Prof. Tugan-Baranovsky* as his most respected *Teacher*. At later date, *Prof. Simon Kuznets*, obtained his *high degree* and 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 *Prof. Joseph Alois Schumpeter* and *Prof. Nikolai D. Kondratiev* research ideas/papers and coming up with the remarkable research results, published at *Harvard University* in the *USA*, 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 at *National Scientific Centre Kharkiv Institute of Physics and Technology / V. N. Karazin Kharkiv National University* 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 the beginning of 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.

In the *quantum computing*, the *second author's scientific views* were mainly influenced 1) by *Prof. Lev Landau research papers* on the *quantum physics*, which have been absorbed during his *research work* in the *City of Kharkiv* in the *State of Ukraine* in 1990s; and 2) by *Prof. Niels Bohr research articles* on the *quantum physics*, which have been studied during his *scientific work* at *Technical University of Denmark* in the *City of Lyngby* near the *City of Copenhagen* in the *State of Denmark* in *Scandinavia* in 1995, 1997-1998; and 3) by *Prof. Heike Kamerlingh Onnes research discoveries*, which have been researched during his *scientific visit* to *Leiden University* in the *State of The Netherlands* in 1998.

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, the *superconducting microwave resonators*, among other *research programs* 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)*, *Quadrature Amplitude Modulation (QAM)*, *Phase Shift Keying (BPSK, QPSK, MPSK)*, *Frequency Shift Keying (FSK)*, *Gaussian Minimum Shift Keying (GMSK)*, etc.

The *second author* has been greatly influenced by the *Henry George's scientific ideas, articles and books* in the *economics* since the *beginning of 1990s*. The *second author* has had the numerous opportunities to discuss a wide range of research problems in the *economics* during his *frequent visits* to the *international conferences* and his *intensive research work* at *leading universities* in *Europe* and *North America* during *last four decades*.

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 scientific 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 and August, 2015.

The additional research changes have been added by the authors during the visits to the City of Kharkiv in the State of Ukraine in June / July / September, 2015. The obtained research results have been extensively discussed with a number of prominent scientists at the VII International Economic Forum: Innovations, Investments, Kharkiv initiatives at Kharkiv Palace hotel in Kharkiv, Ukraine on September 4, 2015; and at the International Economic Conference: Tugan-Baranovsky's Scientific Heritage and Modern Economics Science at V.N. Karazin Kharkiv National University in Kharkiv, Ukraine on October 15-16, 2015.

The authors' vision is that the leading universities continue to educate the students to and make the research in the old meaningless theories in the classic economics science and the classic finance science, which can not explain the functional principles of the real national economies of scale and scope, because of the imposed scientific limitations. We think that the modern theories in the quantum economics science and the quantum finance science can only explain the functional principles of the real national economies of scale and scope meaningfully.

Let us make a final comment by saying that, in the time of the unlimited presence of and access to the information, knowledge and creative integrative thinking around the Globe, we do believe that the new innovative discoveries in the science and technology could be generated by the talented scientists and inventors at any place in our global increasingly multi-polar World at any time.

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