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Abstract – The research article presents the highly innovative theoretical research results: 1) the new quantum microeconomics theory in the quantum econophysics science is formulated; the idea on the existence of the discrete-time induced quantum transitions of firm's earnings (the firm's value) in the quantum microeconomics theory in the quantum econophysics science is proposed; 2) the formulas (1, 2) to compute the firm's discrete-time EBITDA (the firm's value) changes at the different time moments in the quantum microeconomics theory in the quantum econophysics science is derived; 3) the formulas (3, 4) to calculate the distribution of a number of the firms' excited business processes of certain value at the selected firm's state in the economy of scale and scope in terms of the quantum microeconomics theory in the quantum econophysics science is presented; 4) the notion on the wave function in the quantum microeconomics theories in the quantum econophysics science is introduced; 5) the formulas (5, 6) to predict the firm's discrete-time EBITDA (the firm's value) state changes in the national/global economies at the certain time moment, using the wave functions in the quantum econophysical time-dependent/time independent wave equations in the quantum microeconomic theory in the quantum econophysics science, are derived; 6) the evolutionary shifts from the classic economic theories to the quantum economic theories, from the analogue economic signal processing to the digital economic signal processing, from the continuous-time signal filtering economic prediction techniques to the wave functions computing economic prediction techniques in application to the quantum econophysics science are described; 7) the perspectives of application of the quantum microeconomics theory in the quantum econophysics science with the aim to solve the various economic problems in the real- and speculative- sectors of economic markets are discussed.

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Keywords: theory of firm, quantum theory of firm, firm's performance state prediction problem at the certain time moment, wave function in quantum econophysical wave equation in quantum microeconomics theory in quantum econophysics science, wave function in Schrödinger quantum mechanical wave equation in quantum mechanics science, quantum econophysics, econometrics, nonlinear dynamic economic system, economy of scale and scope, quantum microeconomics.

Introduction

The *modern human civilization* has been established on the basis of the *poly-scientific creative innovative discoveries* in a *number of natural and social sciences*, including the ***economics science***, which studies the *production, distribution and consumption of commodities / products / services* at the *national and global scales* in the *time domain*.

Going from the *scale and scope of the considered scientific problems*, the *economics science* can be conditionally divided on the ***fundamental economics*** and the ***applied economics*** in *Joseph Penso de la Vega (1668, 1996), Mortimer (1765), Smith (1776, 2008)*, *Menger (1871)*, *Bagehot (1873, 1897), von Böhm-Bawerk (1884, 1889, 1921), Hirsch (1896), Bachelier (1900), Schumpeter (1906, 1911, 1933, 1939, 1961, 1939, 1947), Slutsky (1910, 1915 1923), von Mises (1912), Hayek (1931, 1935, 2008; 1948, 1980), Keynes (1936, 1992), Ellis, Metzler (1949), Friedman (1953), Baumol (1957), Debreu (1959), Krugman, Wells (2005)*, *Stiglitz (2005)*:

1. Fundamental economics – a *science* on the *fundamental scientific problems* in the *economics*, including the *fundamental economic problems formulation, theories creation*, *laws writing*, *equations derivation*, *etc*;

2. Applied economics – a *science* on the *applied scientific problems* in the *economics,* including the *macroeconomic performance forecasts for the national/global economies*, *microeconomic performance forecasts for the firms and corporations*, *firm's business indicators forecast*, *firm's economic performance variables computing*, *financial indexes forecasts in the national / international money markets*, *etc*.

Going from the *scale of researched scientific problems*, the *economics science* can be conditionally separated into the ***macroeconomics***, ***microeconomics*** and ***nanoeconomics*** in *Joseph Penso de la Vega (1668, 1996), Mortimer (1765), Smith (1776, 2008)*, *Menger (1871)*, *Bagehot (1873, 1897), von Böhm-Bawerk (1884, 1889, 1921), Hirsch (1896), Bachelier (1900), Schumpeter (1906, 1911, 1933, 1939, 1961, 1939, 1947), Slutsky (1910, 1915 1923), von Mises (1912), Hayek (1931, 1935, 2008; 1948, 1980), Keynes (1936, 1992), Ellis, Metzler (1949), Friedman (1953), Baumol (1957), Debreu (1959), Krugman, Wells (2005)*, *Stiglitz (2005)*:

1. Macroeconomics – a *science* on the *macro-economic processes* in the *national/global economies*, which are characterized by the *economic variables* such as the *national economic input/output*, *employment level*, *inflation level, interrelationships between various economic sectors*, and *macro-credits for the states, etc*;

2. ***Microeconomics*** – a *science* on the *micro-economic processes* in the *national/global economies*, which are characterized by the *economic variables* such as the *firm's earnings, taxes*, *investments*, *performance,* and *micro-credits for the firms, etc*;

3. ***Nanoeconomics*** – a *science* on the *nano-economic processes* in the *national/global economies*, which are characterized by the *economic variables* such as the *time of the ultra high frequency trading in the foreign exchange markets*, *volume of the ultra high frequency trading in the foreign exchange markets*, and *value of nano-credits for the firms*, *etc*. The *nanoeconomics* term is introduced and defined by the *authors* for the *first time* in *Ledenyov D O, Ledenyov V O (2015h, 2015i).*

Taking to an account all the *expressed historical scientific views* and the *existing scientific schools of thinking*, the ***modern macroeconomics science*** can be conditionally divided on, but not limited to: the ***Hayek macroeconomics school of thinking***, the ***Chicago macroeconomics school of thinking***, the ***Keynes macroeconomics school of thinking***, the ***George macroeconomics school of thinking*** and the ***Marx macroeconomics school of thinking*** in *Joseph Penso de la Vega (1668, 1996), Mortimer (1765), Smith (1776, 2008)*, *Menger (1871)*, *Bagehot (1873, 1897), von Böhm-Bawerk (1884, 1889, 1921), Hirsch (1896), Bachelier (1900), Schumpeter (1906, 1911, 1933, 1939, 1961, 1939, 1947), Slutsky (1910, 1915 1923), von Mises (1912), Hayek (1931, 1935, 2008; 1948, 1980), Keynes (1936, 1992), Ellis, Metzler (1949), Friedman (1953), Baumol (1957), Debreu (1959), Krugman, Wells (2005)*, *Stiglitz (2005)*:

1. ***Hayek macroeconomics school of thinking*** – a *scientific school of thinking in the economics by Friedrich August von Hayek, Austrian born English economist*, creating the *monetary theory that the credit cycles drives the business cycle* and stating his vision that the *economic market is a self-regulating self-adjusting economic system* in *Hayek (1931, 1935, 2008; 1948, 1980)*;

2. ***Chicago macroeconomics school of thinking*** – a *scientific school of thinking in the economics by Friedrich August von Hayek, Austrian born English economist* and *Milton Friedman, American economist*, declaring a statement that the *state can regulate the economic market by the financial and monetary regulations means to a certain extent, because* the *economic market is only a partly self-regulating self-adjusting economic system* in *Hayek (1931, 1935, 2008; 1948, 1980)*, *Friedman (1953, 1976), Stigler (1982, 1988), Coase (1991), Becker (1992), Fogel (1993), Lucas (1995), Fama (2013), Hansen (2013)*;

3. ***Keynes macroeconomics school of thinking*** – a *scientific school of thinking* in the *economics by John Maynard Keynes, English economist*, expressing an opinion that the *state must regulate the economic market by the different economic regulatory means (monetary and*

financial policies) to a certain extent, because the *economic market is a partly self-regulating self-adjusting economic system* in *Keynes (1936, 1992)*;

4. George macroeconomics school of thinking – a *scientific school of thinking* in the *economics by Henry George, American philosopher and economist*, proposing an idea that the *state must regulate the economic market by the single tax on the land value to a certain extent, because* the *economic market is a partly self-regulating self-adjusting economic system* in *George (1879, 1881, 2009), Gerstein (May, 1996, 1999)*;

5. Marx macroeconomics school of thinking – a *scientific school of thinking* in the *economics by Karl Marx, German political philosopher and economist*, advocating a position that the *progress is due to the class struggle*, creating the *labour theory of value,* and promoting the basic idea that the *state must regulate the economic market by means of the planned economy*, *because* the *economic market is not a self-regulating self-adjusting economic system* in *Marx (1867, 1885, 1894)*.

Considering the *accumulated scientific knowledge*, the ***modern microeconomics science*** can be conditionally divided on, but not limited to, the ***Babbage microeconomics school of thinking***, the ***Ueda microeconomics school of thinking***, the ***Jensen microeconomics school of thinking***, the ***Fama microeconomics school of thinking***, the ***Ledenyov microeconomics school of thinking*** in *Babbage (1832), Ueda (1904, 1937), Marshall (1923), Berle, Means (1932a, b), Ohlin (1933), Coase (1937), Barnard (1938, 1948, 1949, 1958), Solow (August 1957), Modigliani, Miller (June 1958), Baumol (1959, 1962), Penrose (1959), Marris (May 1963), Telser (1963), Williamson (1964, 1975, 1988), Cyert, March (1963, 1992), Fogel (1964), Manne (1965), Stigler (1968), Mano (1968-1969, 1970-1971, 1972-1973 1975-1976, 1978, 1980-1981, 1987, 1994, 1995), Black, Scholes (1973), Black, Cox (1976), Merton (1973, 1974), Lee (1975), Jensen, Meckling (1976), Jensen, Ruback (1983), Jensen (1986, September-October 1989, 1993, 2007), Jensen, Murphy (1990), Fama (1980), Fama, Jensen (1983, 1985), Demsetz (1983, 1997), Wernerfelt (1984, 1995), Lode Li (1986), Perrow (1986), Hart, Moore (1990), Hart (2011), Sterman (2000), Williamson (2002), Kantarelis (2007), Spulber (2009), Ledenyov D O, Ledenyov V O(2013b)*, *Ledenyov D O, Ledenyov V O (2015c)*:

1. Babbage microeconomics school of thinking – a *scientific school of thinking* in the *microeconomics by Babbage*, *economist*, who created the *theory of firm* in *Babbage (1832)*;

2. Ueda microeconomics school of thinking – a *scientific school of thinking* in the *microeconomics by Ueda*, *economist*, who contributed to the creation of the *theory of firm* in *Ueda (1904, 1937)*;

3. Jensen microeconomics school of thinking – a *scientific school of thinking* in the *microeconomics by Jensen*, *economist*, who significantly contributed to the *modern theory of firm* in *Jensen, Meckling (1976), Jensen, Ruback (1983), Jensen (1986, September-October 1989, 1993, 2007), Jensen, Murphy (1990), Fama, Jensen (1983, 1985)*;

4. Fama microeconomics school of thinking – a *scientific school of thinking* in the *microeconomics by Fama*, *economist*, who significantly contributed to the *modern theory of firm* in *Fama (1980), Fama, Jensen (1983, 1985)*;

5. Ledenyov D O and Ledenyov V O microeconomics school of thinking – a *scientific school of thinking* in the *microeconomics by Ledenyov D O and Ledenyov V O, philosophers* and *econo-physicists*, who created the *information theory of firm* in *Ledenyov (2013b, 2015c).*

Going from the *existing approaches to research the scientific problems*, the *economics science* can be conditionally treated as the ***classic economics*** and the ***quantum economics*** in *Joseph Penso de la Vega (1668, 1996), Mortimer (1765), Smith (1776, 2008)*, *Menger (1871)*, *Bagehot (1873, 1897), von Böhm-Bawerk (1884, 1889, 1921), Hirsch (1896), Bachelier (1900), Schumpeter (1906, 1911, 1933, 1939, 1961, 1939, 1947), Slutsky (1910, 1915 1923), von Mises (1912), Hayek (1931, 1935, 2008; 1948, 1980), Keynes (1936, 1992), Ellis, Metzler (1949), Friedman (1953), Baumol (1957), Debreu (1959), Krugman, Wells (2005)*, *Stiglitz (2005)*:

1. Classic economics – a *science,* which uses a big number of the *classic macroeconomics, microeconomics* and *nanoeconomics theories*, based on the *continuous-time wave representations*, attempting to explain and predict the *observed economic phenomena* in the *real- and speculative- sectors of economic markets* in the *national and global economies of the scales and scopes* in *Joseph Penso de la Vega (1668, 1996), Mortimer (1765), Smith (1776, 2008)*, *Menger (1871)*;

2. Quantum economics – a *science,* which uses the *quantum macroeconomics, quantum microeconomics* and *quantum nanoeconomics theories*, based on the *discrete-time wave representations*, with the purpose to explain and predict the *observed economic phenomena essence* in the *real- and speculative- sectors of economic markets* in the *national and global economies of the scales and scopes* in *Ledenyov D O, Ledenyov V O (2015h, 2015i).*

Moving forward with *our scientific discussion*, let us explain that there is a *scientific opinion* that the *classic scientific representations* within the *classic economic theories* proved to be *outdated*, *illogical*, *incomplete* and *inaccurate* from the scientific point of view, resulting in the *frequent forecasting errors* as far as the *economic variables change dynamics* in the *macroeconomics, microeconomics* and *nanoeconomics* is concerned. Speaking clearly, the

classic economic theories have the *derived mathematical equations*, which cannot be used to accurately model the *economic variables change dynamics* in the *macroeconomics, microeconomics and nanoeconomics in the time, frequency and scale domains.*

Therefore, thinking about the *quantum economics*, it is logically to assume that the *foundational principles of quantum economics* will help to achieve the *following research goals*:

1. to create the *new innovative quantum economics theories* to logically describe the *macroeconomics, microeconomics and nanoeconomics processes* in the *real- and speculative-sectors of economic markets*;

2. to generate the new innovative *quantum economics theoretical* approaches to solve the *economic forecasting problems* in the *real- and speculative- sectors of economic markets*; and

3. to *accurately model* the *macroeconomics, microeconomics and nanoeconomics processes* in the *real- and speculative- sectors of economic markets*.

Let us emphasis again that, aiming to achieve the outlined research goals, we will use the ***quantum econophysics science***, mainly based on the ***quantum physics science***, with the purpose to formulate the *theoretical postulates* of the ***quantum microeconomics theory*** in the beginning, then we will create the ***theory of the Ledenyov wave function and derive the Ledenyov quantum mechanical wave equation in the quantum microeconomics theories in the quantum econophysics science with the ultimate goal to attempt to create the new theoretical modeling approaches and to accurately predict the firm systemic state changes in the national/global economies at the specific time moment or over the certain time period.***

Now, let us say a *few introductory words* about the ***quantum econophysics science*** in *Ledenyov D O, Ledenyov V O (2015h)*. As we know, the *quantum econophysics science greatly* complements our knowledge in the *classic econophysics science*, which has been created, using the scientific discoveries in the *econometrics science* and the *classic econophysics science* in *Schumpeter (1906, 1933), Bowley (1924)*, *Fogel (1964)*, *Box, Jenkins (1970)*, *Grangel, Newbold (1977)*, *Van Horne (1984)*, *Taylor S (1986), Tong (1986, 1990)*, *Judge, Hill, Griffiths, Lee, Lutkepol (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), Cameron, Trivedi (2005), Iyetomi, Aoyama, Ikeda, Souma, Fujiwara (2008)*, *Iyetomi, Aoyama, Fujiwara, Sato (editors) (2012), Vialar, Goergen (2009)*. Moreover, as it was discussed in *Ledenyov D O, Ledenyov V O (2015h),* the *quantum econophysics science* includes the *fundamental principles* of

the ***quantum physics science***, which have been created in the beginning of *XX century* and further developed over *XX – XXI centuries* 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), McMahon (2006), Halliday (2007), Hand, Finch (2008), Teschl (2009), Zettili (2009), Laloe (2012)*.

Speaking clearly about the *foundations of the quantum physics science*, it is necessary to explain that it was shown in *quantum physics science* that the ***discrete nature of microscopic physical world manifests in the quantization of energy spectrum of electronic excitations, which can be mathematically described by 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), McMahon (2006), Halliday (2007), Hand, Finch (2008), Teschl (2009), Zettili (2009), Laloe (2012)*. For example, the *atom model* in the *condensed matter physics* in *Bohr (1922)* in which the *electrons* rotate at the *distant discrete orbits* around the *nucleus*, having the *quantized energy spectrum*, was created in the *quantum physics science*.

Discussing the numerous ***applications of the quantum physics***, it is necessary to say that the *nuclear reactors* at the *nuclear power plants* as well as the *quantum electronic devices* have been developed due to the *ongoing considerable progress* in the *quantum physics*:

1. The *nuclear energy generation* with the *various types of nuclear reactors* is achieved in *Fermi (1934), Fermi, Amaldi, d'Agostino, Rasetti, Segre (1934), Blokhintsev (1954)*;

2. The *new quantum electronics devices* are successfully developed:

a) the *high power gas lasers* in *Townes (1939, 1964, 1966, 1969, 1995, 1999), Townes, Schawlow (1955), Gordon, Zeiger, Townes (1955), Shimoda, Wang, Townes (1956), Prokhorov, Basov (1955), Prokhorov, Fedorov (1963), Prokhorov (1964, 1965, 1979), Karlov, Prokhorov (1976), Prokhorov, Buzzi, Sprangle, Wille (1992), Schawlow, Townes (1958), Schawlow (1963, 1964), Gould (1959), Basov (1964, 1965)*;

b) the *semiconductor heterostructures lasers* in *Townes (1939, 1964, 1966, 1969, 1995, 1999), Townes, Schawlow (1955), Gordon, Zeiger, Townes (1955), Shimoda, Wang, Townes (1956), Prokhorov, Basov (1955), Prokhorov, Fedorov (1963), Prokhorov (1964, 1965, 1979), Karlov, Prokhorov (1976), Prokhorov, Buzzi, Sprangle, Wille (1992), Schawlow, Townes (1958), Schawlow (1963, 1964), Gould (1959), Basov (1964, 1965), Yokoyama, Ujihara (1995), Alferov (1996), Milonni, Eberly (1998), Bimberg, Grundmann, Ledentsov (1999)*;

c) the various types of *semiconductor / superconductor / metal heterostructures transistors*, including the *single electron transistor, single electron quantum dot transistor, in which the discrete charge carriers quantum tunneling effects are present* in *Bardeen (1956), Fulton, Dolan (1987), Grabert, Devoret (1992), Mygind (1997)*;

d) the *Josephson junctions in Josephson (1962, 1964, 1965)* and the *dc/rf superconducting quantum interference devices (SQUIDs)* in *Tesche, Clarke (1977), Clarke (1989), Muck (1998), Bardeen (1972, 1990)*;

e) the *quantum random number generators on magnetic flux qubits (1024QRNG_MFQ)* in *Ledenyov V O, Ledenyov O P, Ledenyov D O (2002), Ledenyov D O, Ledenyov V O (2015a)*.

Let us continue a *short introductory discussion* on the *quantum mechanics* and *quantum physics*, by saying that, using the research findings in *de Broglie (1924, 1925, 1926)*, *Erwin Schrödinger, Austrian physicist* introduced the notion of the ***wave function*** and derived the ***Schrödinger quantum mechanical wave equation,*** which is a *partial differential equation* to describe all the *changes of a quantum state of a physical system* over the *certain time period* in *Schrödinger (1926a,b, 1982, 1984)* in the frames of 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), McMahon (2006), Halliday (2007), Hand, Finch (2008), Teschl (2009), Zettili (2009), Laloe (2012).

Moving ahead to the discussion on the main scientific problems of our interest, the *authors* would like to say that we intend to consider the *following five research problems* in this *research article* in details:

1. *The quantum microeconomics theory formulation in the quantum econophysics science*;

2. The *formula derivation to describe the discrete-time EBITDA changes during the firm's economic performance variations in terms of the quantum microeconomics theory in the quantum econophysics science*;

3. The *formula derivation to explain the distribution of a number of excited firms' business processes of certain value at the selected level (state) in the economy of scale and scope in terms of the quantum microeconomics theory in the quantum econophysics science*;

4. The *formula derivation to predict the firm's possible economic performance state changes in the national/global economies at the certain time moment, using the wave function in the quantum econophysical wave equation in the quantum microeconomic theory in the quantum econophysics science*;

5. The *concluding remarks summary on the perspectives of application of the quantum microeconomics theory in the quantum econophysics science with the aim to solve the various economic challenges in the real- and speculative- sectors of economic markets*.

Quantum microeconomics theory and its applications

"***Microeconomics is a branch of economics that studies the behaviour of individuals and firms in making decisions regarding the allocation of limited resources***," as it is explained in *Wikipedia (2015k).*

The *authors* provided the concise *definition* of the ***microeconomics science*** in *Ledenyov D O, Ledenyov V O (2015i)*: "***Microeconomics***, as a *science* on the *micro-economic processes* in the *national/global economies*, centers around the *modern theory of firm* and researches the *economic variables* such as the *firm's earnings, taxes*, *investments*, *performance,* and *micro-credits for the firms* in *Babbage (1832), Ueda (1904, 1937), Marshall (1923), Berle, Means (1932a, b), Ohlin (1933), Coase (1937), Barnard (1938, 1948, 1949, 1958), Solow (August 1957), Modigliani, Miller (June 1958), Baumol (1959, 1962), Penrose (1959), Marris (May 1963), Telser (1963), Williamson (1964, 1975, 1988), Cyert, March (1963, 1992), Fogel (1964),*

Manne (1965), Stigler (1968), Mano (1968-1969, 1970-1971, 1972-1973 1975-1976, 1978, 1980-1981, 1987, 1994, 1995), Black, Scholes (1973), Black, Cox (1976), Merton (1973, 1974), Crew (1975), *Lee (1975), Jensen, Meckling (1976), Jensen, Ruback (1983), Jensen (1986, September-October 1989, 1993, 2007), Jensen, Murphy (1990), Fama (1980), Fama, Jensen (1983, 1985), Demsetz (1983, 1997), Wernerfelt (1984, 1995), Lode Li (1986), Perrow (1986), Hart, Moore (1990), Hart (2011), Sterman (2000), Williamson (2002), Kantarelis (2007), Spulber (2009), Ledenyov D O, Ledenyov V O(2013b)*, *Ledenyov D O, Ledenyov V O (2015c)*."

In the *microeconomics* in the *classic economics science*, the process of the *firm's evolution* has the *three stages* in *Ledenyov D O, Ledenyov VO (2013b, 2015c)*: "the ***evolution of the firm*** includes the *three clearly identified stages* in *Chandler (1962, 1977, 1993, 1994, 1998, 2001, 2005), Chandler, Daems (1980), Ledenyov D O, Ledenyov VO (2013b)*:

1) *Barriers to entry creation*,

2) *Strategic boundaries definition*,

3) *Limits to growth evaluation*."

The ***theory of firm*** studies the *firm's organizational structure*, the *firm's functional performance*, and the *firm's economic variables change forecast*. A number of the *possible* ***theories of the firm***, including the *information theory of the firm* in *Ledenyov D O, Ledenyov V O (2015c)*, have been created by *many distinguished scientists* in *Babbage (1832), Ueda (1904, 1937), Marshall (1923), Berle, Means (1932a, b), Ohlin (1933), Coase (1937), Barnard (1938, 1948, 1949, 1958), Solow (August 1957), Modigliani, Miller (June 1958), Baumol (1959, 1962), Penrose (1959), Marris (May 1963), Telser (1963), Williamson (1964, 1975, 1988), Cyert, March (1963, 1992), Fogel (1964), Manne (1965), Stigler (1968), Mano (1968-1969, 1970-1971, 1972-1973 1975-1976, 1978, 1980-1981, 1987, 1994, 1995), Black, Scholes (1973), Black, Cox (1976), Merton (1973, 1974), Crew (1975)*, *Lee (1975), Jensen, Meckling (1976), Jensen, Ruback (1983), Jensen (1986, September-October 1989, 1993, 2007), Jensen, Murphy (1990), Fama (1980), Fama, Jensen (1983, 1985), Demsetz (1983, 1997), Wernerfelt (1984, 1995), Lode Li (1986), Perrow (1986), Hart, Moore (1990), Hart (2011), Sterman (2000), Williamson (2002), Kantarelis (2007), Spulber (2009), Ledenyov D O, Ledenyov V O(2013b, 2015c)*. Let us review the ***existing modern theories of the firm***, *created* by the prominent thinkers and described in the *microeconomics* in the *classic economics science* in *Ledenyov D O, Ledenyov VO (2013b, 2015c)*:

1. "The ***neo-classical theory of the firm*** describes the various market structures, regulation issues, strategic pricing, barriers to entry, economies of scale and scope and even optimum portfolio selection of risky assets, and establishes the principle of profit maximisation, according

to which profit is maximised, when marginal revenue is equal to marginal cost in the conditions of complete information. The theory does not allow for firm evolution in *Berle, Means (1932a, b), Kantarelis (2007).*

2. The ***transaction cost theory of the firm*** states that the people begin to organise their production in the firms, when the transaction cost of coordinating production through the market exchange in the conditions of the imperfect information, is greater than within the firm in *Coase (1937).* It does not take into consideration agency costs or firm evolution, neither does it explain how vertical integration should take place in the face of investments in human assets, with unobservable value, that cannot be transferred in *Kantarelis (2007).*

3. The ***managerial theory of the firm*** suggests that the managers would seek to maximise their own utility and consider the implications of this for firm behaviour in contrast to the profit-maximising case in *Baumol (1959, 1962)*, *Marris (1964)* and *Williamson (1966).*

4. The ***principal–agent theory of the firm*** extends the ***neo-classical theory of the firm*** and ***managerial theory of the firm*** by adding agents to the firm, and it considers the friction due to asymmetric information between owners of firms and their stakeholders or managers and employees; the friction between agent and principal requires precise measurement of agent performance and the engineering of incentive mechanisms. The weaknesses of the theory are many: it is difficult to engineer incentive mechanisms, it relies on complicated incomplete contracts (borderline unenforceable), it ignores transaction costs (both external and internal), and it does not allow for firm evolution in *Spence and Zeckhauser (1971)*, *Ross (1973)*, *Kantarelis (2007).*

5. The ***behavioural theory of the firm*** assumes that the groups of people participate in setting goals and making decisions on the production; inventory; market share; sales and profits in the firm, potentially creating conflicts. The theory proposes that the real firms aim to satisfy rather than maximize their results in agreement with the bounded rationality concept in *Simon (1950)*, *Cyert, March (1963).*

6. The ***evolutionary theory of the firm*** states that the firm possesses unique resources (the resource based view of the firm): financial, physical, human and organizational. It sees the firm as a reactor to change and a creator of change for competitive advantage. The firm, as a creator of change, may cause creative destruction, which in turn may give birth to new industries and enable sectors of, or entire, economies to grow. The theory does not take to the account that the creative innovation process cannot be easily programmed within a firm or a nation in *Penrose (1959)*, *Wernerfelt (1984)*, *Barney (1991)*, *Kantarelis (2007).*

7. The ***knowledge theory of firm*** permits that the firm has a knowledge base, which represents the most strategically significant resource of the firm, providing the competitive advantage to the firm in *Kogut, Zander (1992, 2000)*, *Nonaka, Takeuchi (1995)*, *Foss (1996)*, *Grant (1996a, b, c)*, *Spender (1996)*, *Alavi, Leidner (March 2001)*, *Nickerson, Zander (2004)*. The *knowledge theory of firm* in *Kogut, Zander (1992, 2000)*, *Nonaka, Takeuchi (1995)*, *Foss (1996)*, *Grant (1996a, b, c)*, *Spender (1996)*, *Alavi, Leidner (March 2001)*, *Nickerson, Zander (2004)* extends the *evolutionary theory of the firm* in *Penrose (1959)*, *Wernerfelt (1984)*, *Barney (1991)*, *Kantarelis (2007)* to some degree.

8. The ***information theory of firm*** describes the firm in terms of the information computing and processing processes *Ledenyov D O, Ledenyov VO (2015c)*. The main distinction of the *information theory of firm* from the *knowledge theory of firm* is in the fact that the *information theory of firm* characterizes the *firm* by means of the *dynamic information flow and processing* processes. In other words, the *information theory of firm* is a truly *dynamic theory of the firm*, but not a *static theory of the firm* as in the case of all other theories.

Discussing the *firm's earnings forecast problem*, it makes sense to highlight an *interesting fact* that the *firm's value* (the *firm's earnings: EBITDA*) is usually computed and forecasted, using the *continuous-time wave models* in the *classic microeconomics theory* in the *classic economics science*. However, there is a *scientific opinion* that the *functional nature of the modern firm is discrete, because the main parameters of the firm tend to change discretely in the time domain*. Therefore, the *authors* proposed that the *firm* can be better characterized by the *discrete-time wave models* in the *quantum microeconomics* in the *quantum economics science* in *Ledenyov D O, Ledenyov V O (2015i)*.

As we know the ***quantum microeconomics theory*** has been formulated in *Ledenyov D O, Ledenyov V O (2015i)* for the *first time*: "Let us formulate the ***quantum microeconomics theory*** for the *first time:* ***The quantum microeconomics theory postulates that the discrete-time transitions from one level of the firm's economic performance to another level of the firm's economic performance will occur in the nonlinear dynamic economic systems at the time moment, when:***

1. The land, labour and capital resources are (added and absorbed) / (released and radiated) in the form of quanta, decreasing or increasing the general energy entropy in the nonlinear dynamic economic system (the nonlinear medium);

2. The disruptive scientific/technological/financial/social/political innovation(s) is/are introduced into or withdrawn from the nonlinear dynamic economic system (the nonlinear medium), creating the resonance conditions to amplify/attenuate the value of firm's

economic performance, during the evolution process of the economy of scale and scope in the time domain (Note: the resonance can result in the increase/decrease of the energy of the electromagnetic wave in the electrodynamics science);

3. The derived formula to describe the ***discrete-time EBITDA changes during the firm's economic performance variations in terms of the quantum microeconomics theory*** is

$$ł_{micro}\omega_{m,n} = \triangle \boldsymbol{EBITDA}(t) = \boldsymbol{EBITDA}\left(t\right)_m - \boldsymbol{EBITDA}\left(t\right)_n \quad \textbf{(1)}$$

$$ł_{micro}\omega_{m,n} = \triangle \boldsymbol{firm's\ \ value}(t) = \boldsymbol{firm's\ \ value}\left(t\right)_m - \boldsymbol{firm's\ \ value}\left(t\right)_n \quad \textbf{(2)}$$

where: $ł_{micro}$ – *Ledenyov constant*,

ω – *cyclic velocity*,

t – time,

EBITDA – the *Earnings Before Interest Tax Depreciation Amortization,*

Firm's value – the *firm's market capitalization* minus the *firm's long term investments and debt*.

4. The ***Ledenyov distribution of a number of excited firms' business processes of certain value at the selected level (state) in the economy of scale and scope in terms of the quantum microeconomics theory*** is

$$\frac{\boldsymbol{N}_m}{\boldsymbol{N}_n} = \exp\frac{-\left(\boldsymbol{EBIDTA}\left(t\right)_m - \boldsymbol{EBIDTA}\left(t\right)_n\right)}{ƛ_{micro}\boldsymbol{T}}, \quad \textbf{(3)}$$

$$\frac{\boldsymbol{N}_m}{\boldsymbol{N}_n} = \exp\frac{-\left(\boldsymbol{firm's\ \ value}\left(t\right)_m - \boldsymbol{firm's\ \ value}\left(t\right)_n\right)}{ƛ_{micro}\boldsymbol{T}}, \quad \textbf{(4)}$$

where: $ƛ_{micro}$ – *Ledenyov constant*,

$\boldsymbol{N}_m$ – *number of firms' processes of certain value at the state (m)*,

$\boldsymbol{N}_n$ – *number of firms' business processes of certain value at the state (n)*,

$\boldsymbol{N} = \boldsymbol{N}_m + \boldsymbol{N}_n$ – *general number of firms' processes of certain value in the economy of scale and scope,*

t – time,

T – temperature of the economy of scale and scope, which corresponds to the level of entropy of the economy of scale and scope (the level of information/business activities by the firms),

EBITDA – the *Earnings Before Interest Tax Depreciation and Amortization,*

Firm's value – the *firm's market capitalization* minus the *firm's long term investments and debt*.

In other words, let us emphasis that the *quantum microeconomics theory* states that there may be the *discrete-time induced transition(s) between the different levels of the firm's EBITDAs* (the firm's values) in the *nonlinear dynamic economic system* at the *time*, *when* the following things are present:

1. the ***land, labour and capital****, which can be added and absorbed / released and radiated in the form of quanta in the nonlinear dynamic economic system (the nonlinear medium)*;

2. the ***discrete-time fluctuational processes****, which can appear in the form of* the *disruptive scientific/technological/financial/social/political innovation(s) that absorb* or *release* the available *land, labour and capital resources*, creating the *resonance,* in the *nonlinear dynamic economic system (the nonlinear medium)* during the *evolution process of* the *firm* in the *economy of scale and scope* in the *time domain*;

3. the ***firms' business processes population inversion mechanism****, which occurs at the following condition:* $N_2/N_1 > 1$."

The *authors* would like to add that there are many possible ***disruptive scientific/technological/financial/social/political innovations*** in *Ledenyov D O, Ledenyov V O (2015h, i)*: "Let us give the possible examples of the above discussed ***disruptive scientific/technological/financial/social/political innovation(s)***:

1. ***Scientific innovation****: the discovery of new scientific phenomena and laws such as the relativity law in the physics* in *Landes (1998)*;

2. ***Technological innovation****: the creation of new materials / devices such as the new metals / steam engines, new metals / combustion engines, semiconductors / transistors, semiconductors / lasers, superconductors / electric motors, superconductors / single electron transistors, superconductors / Josephson junctions, superconductors / quantum random number generators, superconductors / quantum processors* in *Ledenyov D O, Ledenyov V O (2015a)*;

3. ***Financial innovation****: the creation of new financial products and services such as the derivatives and mobile banking*;

4. ***Social innovation****: the introduction of new socioeconomic models, for instance: the shared-value initiative, which can be defined as: "the policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates" in Porter, Kramer (2006, 2011)*;

5. ***Political innovation****: the establishment of the new effective governmental system.*"

The *quantum microeconomics theory* opens a number of new opportunities to tackle the *economic and financial forecasts problems*, hence the ***formula to predict the firm's economic performance state changes in the national/global economies at the certain time moment can be derived, using the wave function in the quantum econophysical wave equation in the quantum microeconomic theory in the quantum econophysics science*** as it was shown in *Ledenyov D O, Ledenyov V O (2015i)*.

Therefore, let us derive a *set of the complete formulas* ***to predict the firm's economic performance state changes in the national/global economies at the certain time moment, using the wave function in the quantum econophysical wave equation in the quantum microeconomic theory in the quantum econophysics science*** as in *Ledenyov D O, Ledenyov V O (2015i)*, making *some additional clarifications*:

"Let us write the ***time dependent Ledenyov quantum econophysical wave equation*** in the ***quantum microeconomics theory*** in the ***quantum econophysics science***

$$i\hbar_{micro}\frac{\partial}{\partial t}w_{micro} = \hat{L}_{micro}w_{micro}, \tag{5}$$

where: i – the *imaginary unit*,

w_{micro} – the wave function of a quantum system, which is a mathematical function in the quantum mechanics to accurately characterize a specified state of a quantum 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.

$\hbar_{micro}$ – the *Ledenyov constant*,

t – the *time*,

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

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

The ***time independent Ledenyov quantum econophysical wave equation*** in the ***quantum microeconomics theory*** in the ***quantum econophysics science*** is

$$E_{micro}w_{micro} = \hat{L}_{micro}w_{micro}, \tag{6}$$

where: w_{micro} – the *wave function of a quantum system, which is a mathematical function in the quantum mechanics to accurately characterize a specified state of a quantum 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*,

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

$\boldsymbol{E}_{micro}$ – the *energy of the state* $\boldsymbol{w}_{micro}$."

Continuing the *scientific discussion*, the *authors* would like to comment that we know that: "*the wave function is considered as a natural attribute of quantum mechanics*" in *Rylov (2015*).

The *authors* think that ***the Ledenyov wave function in the Ledenyov quantum econophysical wave equation in the quantum microeconomics theory in the quantum econophysics science can be regarded as the probability density wave and it can be used to accurately characterize and predict the firm's economic state changes in the national/global economies at the certain time moment.*** This clarification is made by the *authors*, using the *obtained knowledge* in the ***quantum mechanics*** 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), McMahon (2006), Halliday (2007), Hand, Finch (2008), Teschl (2009), Zettili (2009), Laloe (2012)*, *Rylov (2015)* and the ***probability theory in the mathematics*** *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).*

In general, the *authors* believe that ***the Ledenyov wave function in the Ledenyov quantum econophysical wave equation represents a most complete accurate characterization that can be given to the firm's economic performance state in the microeconomic system in agreement with the quantum microeconomic theory in the quantum econophysics science***.

Conclusion

This *research article* presents a number of the *highly innovative theoretical research results*:

1. the *new quantum microeconomics theory in the quantum econophysics science is formulated*;

2. the *idea on the existence of the discrete-time induced quantum transitions of firm's earnings (the firm's value) in the quantum microeconomics theory in the quantum econophysics science is proposed*;

3. the *formulas (1, 2) to compute the firm's discrete-time EBITDA (the firm's value) changes at the different time moments in the quantum microeconomics theory in the quantum econophysics science is derived*;

4. the *formula, (3, 4) to calculate the distribution of a number of the firms' excited business processes of certain value at the selected firm's state in the economy of scale and scope in terms of the quantum microeconomics theory in the quantum econophysics science is presented*;

5. the *notion on the wave function in the quantum microeconomics theories in the quantum econophysics science is introduced*;

6. the *formulas (5) and (6) to predict the firm's discrete-time EBITDA (the firm's value) state changes in the national/global economies at the certain time moment, using the wave functions in the quantum econophysical time-dependent/time independent wave equations in the quantum microeconomic theory in the quantum econophysics science, are derived*;

7. the *evolutionary shifts from the classic economic theories to the quantum economic theories, from the analogue economic signal processing to the digital economic signal processing, from the continuous-time signal filtering economic prediction techniques to the wave functions computing economic prediction techniques in application to the quantum econophysics science are established*;

8. the *perspectives of software program development to solve the various economic problems in the real- and speculative- sectors of economic markets, using the new quantum microeconomics theory in the quantum econophysics science, are discussed*.

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 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*.

The *second author's scientific views* were mainly influenced 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 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*.

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)*, *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 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*.

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