Precise measurement of macroeconomic variables in time domain using three dimensional wave diagrams

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Abstract – Article considers a research problem on the precise measurement of the macroeconomic variables changes in the time domain in the macroeconomics science. We propose to use the three dimensional (3D) wave diagram in the macroeconomics science for the first time, aiming to accurately characterize and to clearly visualize the GIP(t)/GDP(t)/GNP(t)/PPP(t) dependences changes in the time domain. We explain that the three dimensional (3D) wave diagram in the macroeconomics science has been created, using the theory on the continuous-time waves with the rotating polarization vector in the electrodynamics science. We show that the three dimensional (3D) wave diagram in the macroeconomics science can be used to accurately characterize and finely display the GIP(t), GDP(t), GNP(t), PPP(t) dependences changes in the time domain in the two possible cases: 1) the continuous-time waves of GIP(t), GDP(t), GNP(t), PPP(t) and 2) the discrete-time waves of GIP(t), GDP(t), GNP(t), PPP(t). We conclude that an introduction of the three dimensional (3D) wave diagram in the macroeconomics science can help to solve a challenging research problem on the precise measurement of the macroeconomic variables changes in the time domain.

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Keywords: three dimensional (3D) wave diagram, dependence of general information product on time GIP(t), dependence of general domestic product on time GDP(t), dependence of general national product on time GDP(t), dependence of purchase power parity on time PPP(t), continuous-time signals, spectrum analysis of continuous-time signals, amplitude / frequency / wavelength / period / phase of continuous-time signal, mixing / harmonics / nonlinearities of continuous-time signals, continuous-time waves with rotating polarization vector, continuous-time signal generators, discrete-time signals, spectrum analysis of discrete-time signals, amplitude / frequency / wavelength / period / phase of discrete-time digital signal, mixing / harmonics / nonlinearities of discrete-time digital signals, Ledenyov discrete-time digital waves, discrete-time digital signals generators, Juglar fixed investment cycle, Kitchin inventory cycle, Kondratieff long wave cycle, Kuznets infrastructural investment cycle, nonlinear dynamic economic system, economy of scale and scope, macroeconomics science, econometrics science, electrodynamics science, econophysics science.
Introduction

In the natural sciences, the cut, color, clarity, carat weight of a pink/yellow/white diamond determine the value of a pink/yellow/white diamond precisely.

In the social sciences, the level of philosophical thinking on the problems of fundamental economics science defines a state of economical/social progress in the economy of scale and scope in any country of research interest accurately. The high level of philosophical thinking on the problems of fundamental economics resulted in a formulation and implementation of a set of progressive state policies towards the new limitless opportunities to build the economical/social prosperity in the economies of scale and scope in the leading countries. The philosophical thinking on the problems of fundamental economics in the process of research by the talented scientists with application of an accumulated knowledge base has been conducted 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), Slatsky (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, 2015).

The five main types of the business cycles in the macroeconomics science have been discovered:

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

For many years, an old scientific opinion was that the above business cycles belong to a group of the continuous waves (the continuous-time signals), because their main parameters such as the amplitude / frequency / wavelength / period / phase change continuously in the time domain. In addition, it was generally accepted to think that the dependence of the General Domestic Product on the time GDP(t) can be viewed as a continuous-time fluctuation of the economy output in the form of the oscillating quantity of the produced goods and provided services in the economy of scale and scope over the specified time period, hence the GDP(t) can be used with the purpose to accurately characterize the macroeconomic processes in the economies of scales and scopes in Kuznets (1973a, b).

The interesting research proposal in macroeconomics science is that the 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). It was shown that these discrete-time digital waves may have the multiple origins and can be generated by the discrete-time economical, financial, political and social events such as the disruptive innovations in Christensen, Denning (December 2015) in the economies of scales and scopes in the time domain in Ledenyov D O, Ledenyov V O (2013c, 2015d, 2015e). In other words, it was suggested that the dependence of general information product on time GIP(t), dependence of general domestic product on time GDP(t), dependence of general national product on time GDP(t), dependence of purchase power parity on time PPP(t) can be considered as the discrete-time fluctuations of the economy output in the form of the oscillating quantity of the produced goods and the provided services and the purchasing power and the generated information streams in the economy of scale and scope over the specified time period, which can quite accurately characterize the macroeconomic processes in the economies of scales and scopes in the time domain in Ledenyov D O, Ledenyov V O (2013c, 2015d, 2015e).
Therefore, as it was discovered in Ledenyov D O, Ledenyov V O (2013c, 2015d, 2015e), the five main types of the business cycles in the modern macroeconomics science are:

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

In this research article, we would like to discuss the precise measurement of macroeconomic variables in the time domain using the three dimensional wave diagrams. Thus, completing a short insightful introduction, let us begin a more detailed scientific discussion and present our original research thoughts on the subject of scientific interest in this research article.

Precise measurement of macroeconomic variables in time domain using three dimensional wave diagrams

Let us consider the research problem on the precise measurement of changes of the macroeconomic variables in the macroeconomics science in the time domain. In the macroeconomics, the dependence of the general information product on the time GIP(t), the dependence of general domestic product on the time GDP(t), the dependence of the general national product on the time GDP(t), the dependence of the purchase power parity on the time PPP(t) are usually shown in the form of the two dimensions charts of GIP(t), GDP(t), GNP(t), PPP(t).

However, the scientific problem in the macroeconomics is that, looking at the dependences of GIP(t), GDP(t), GNP(t), PPP(t), it is not possible to answer the question: What are the separate contributions by the output of the real sector of the economy of scale and scope and by the output of the speculative sector of the economy of scale and scope to the general information product on the time GIP(t), the general domestic product on the time GDP(t), the general national product on time GDP(t), the purchase power parity on the time PPP(t)?

In the macroeconomics, the clear separation of the contributions by the real sector of the economy of scale and scope and by the speculative sector of the economy of scale and scope to the total resulting magnitude of GIP(t), GDP(t), GNP(t), PPP(t) is quite important. Presently, the
reported quantities of $GIP(t), GDP(t), GNP(t), PPP(t)$ can be considered as meaningless by the economists in view of the fact that it is frequently not possible to distinguish the contributions by the real sector of the economy of scale and scope and by the speculative sector of the economy of scale and scope to the total resulting magnitude of $GIP(t), GDP(t), GNP(t), PPP(t)$.

Let us explain that a huge increase of the monetary base by means of the money supply increase during the quantitative easing programs implementation by the central banks in the economies of scales and scopes in the developed/developing countries may lead to the situation, when the investment banks, investment funds, commerce banks, which obtain a lot of money from the central banks, contribute to the growth of $GIP(t), GDP(t), GNP(t), PPP(t)$ mainly. In other words, the $GIP(t), GDP(t), GNP(t), PPP(t)$ increase disproportionally, because of the increasing contributions by the speculative sectors of the economies of the scales and scopes as a result of huge increase of monetary bases due to the quantitative easing programs implementations by the central banks in the economies of scales and scopes in the developed/developing countries. At the same time, when the $GIP(t), GDP(t), GNP(t), PPP(t)$ increase disproportionally, the contributions by the real sectors of the economies of the scales and scopes to the changes of $GIP(t), GDP(t), GNP(t), PPP(t)$ in the economies of the scales and scopes may actually decrease / not change / modestly increase, depending on various factors.

Therefore, we propose to use the three dimensional (3D) wave diagram in the macroeconomics science for the first time, aiming to accurately characterize and to clearly visualize all the contributions by the real sector of the economy of scale and scope as well as the speculative sector of the economy of scale and scope to the final resulting change of $GIP(t)/GDP(t)/GNP(t)/PPP(t)$. We explain that the three dimensional (3D) wave diagram in the macroeconomics science has been created, using the theory on the continuous-time waves with the rotating circular polarization vector in the electrodynamics science. We would like to comment that, in the electrodynamics science, the continuous-time electro-magnetic waves with the rotating circular polarization vector have been well researched over the years in Wikipedia (2016i, j). The continuous-time electro-magnetic waves with the rotating circular polarization vector are usually used in the process of the information transmission over the ground-to-space and the space-to-ground satellite communication links. Also, the continuous-time electro-magnetic waves with the rotating circular polarization vector are normally applied in the process of the information transmission over the fiber optics communication channels.

In Fig. 1, we would like to show the proposed three dimensional (3D) wave diagram in the macroeconomics science, which can be used to accurately characterize and to finely display
the $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$ dependences changes in the time domain in the two possible cases:

1. the continuous-time waves of $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$, and
2. the discrete-time waves of $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$.

![3D wave diagram](image)

**Fig. 1.** 3D wave diagram, which shows changes of dependences of $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$ in time domain.

Let us explain the 3D Wave Diagram by saying that the total $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$ is a sum of the two components, including the real $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$ and the speculative $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$.

The total magnitude of $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$ can change as the continuous-time wave in agreement with the old economic representations in Kitchin (1923), Juglar (1862), Kuznets (1973a, b), Kondratieff, Stolper (1935) or as the discrete-time wave in accordance with the new economic representations in Ledenyov D O, Ledenyov V O (2013c, 2015d, 2015e).

The phase angle $\phi$ defines the tilt of $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$ and it depends on the magnitude of the real $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$ and the magnitude of the speculative $GIP(t)$, $GDP(t)$, $GNP(t)$, $PPP(t)$.
We have developed the software program, MacroSoft, which creates the proposed three dimensional (3D) wave diagram to accurately characterize and to finely display the GIP(t), GDP(t), GNP(t), PPP(t) dependences for the G7 economies of the scales and scopes in the time domain for the two possible cases:

3. the continuous-time waves of GIP(t), GDP(t), GNP(t), PPP(t), and
4. the discrete-time waves of GIP(t), GDP(t), GNP(t), PPP(t).

Let us conclude that an introduction of the three dimensional (3D) wave diagram in the macroeconomics science can help to solve a challenging research problem on the precise measurement of the macroeconomic variables in the time domain.

Conclusion

This article considers a research problem on the precise measurement of the macroeconomic variables changes in the time domain in the macroeconomics science.

We propose to use the three dimensional (3D) wave diagram in the macroeconomics science for the first time, aiming to accurately characterize and to clearly visualize the GIP(t)/GDP(t)/GNP(t)/PPP(t) dependences changes in the time domain.

We explain that the three dimensional (3D) wave diagram in the macroeconomics science has been created, using an analogy with the theory on the continuous-time waves with the rotating polarization vector in the electrodynamics science.

We show that the three dimensional (3D) wave diagram in the macroeconomics science can be used to accurately characterize and finely display the GIP(t), GDP(t), GNP(t), PPP(t) dependences changes in the time domain in the two possible cases:

5. the continuous-time waves of GIP(t), GDP(t), GNP(t), PPP(t), and
6. the discrete-time waves of GIP(t), GDP(t), GNP(t), PPP(t).

We conclude that an introduction of the three dimensional (3D) wave diagram in the macroeconomics science can help to solve a challenging research problem on the precise measurement of the macroeconomic variables changes in the time domain.

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**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:**

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