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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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), 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, 2015).*

The ***macroeconomics, microeconomics and nanoeconomics*** are the *integral parts* of the *fundamental economics science*. In the ***macroeconomics***, the research on *the business cycles* - the *fluctuations* of the *economy output* in the form of the *oscillating quantity* of the *produced goods* and *provided services* over the *specified time period* in the *economy of scale and scope* – has been conducted in *Juglar (1862), George (1881, 2009), Kondratieff (1922, 1925, 1926, 1928, 1935, 1984, 2002), Kitchin (1923), Schumpeter (1939), Burns, Mitchell (1946), Dupriez (1947), Samuelson (1947), Hicks (1950), Inada, Uzawa (1972), Kuznets (1973a, b), Bernanke (1979), Marchetti (1980), Kleinknecht (1981), Dickson (1983), Hodrick, Prescott (1997), Baxter, King (1999), Kim, Nelson (1999), McConnell, Pérez-Quirós (2000), Devezas, Corredine (2001, 2002), Devezas (editor) (2006), Arnord (2002), Stock, Watson (2002), Helfat, Peteraf (2003), Sussmuth (2003), Hirooka (2006), Kleinknecht, Van der Panne (2006), Jourdon (2008), Taniguchi, Bando, Nakayama (2008), Drehmann, Borio, Tsatsaronis (2011), Iyetomi, Nakayama, Yoshikawa, Aoyama, Fujiwara, Ikeda, Souma (2011), Ikeda, Aoyama, Fujiwara, Iyetomi, Ogimoto, Souma, Yoshikawa (2012), Swiss National Bank (2012, 2013), Uechi, Akutsu (2012), Central Banking Newsdesk (2013), Ledenyov D O, Ledenyov V O (2013c, 2015d, 2015e), Union Bank of Switzerland (2013), Wikipedia (2015a, b, c).*

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).*

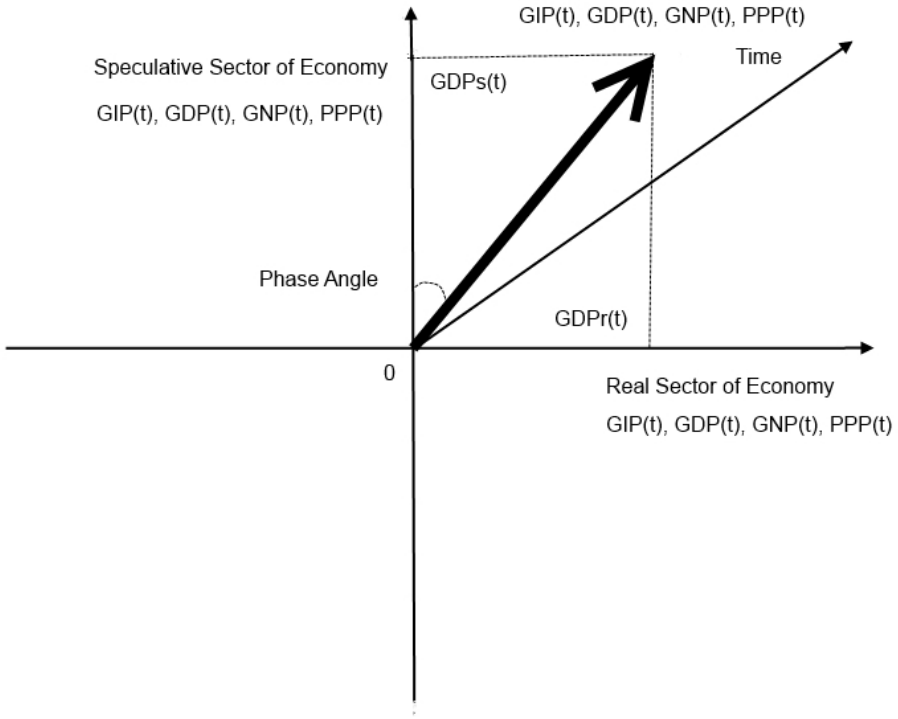

Fig. 1. *3D wave diagram, which shows changes of dependences of GIP(t), GDP(t), GNP(t), PPP(t) in time domain.*

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* $\boldsymbol{\varphi}$ 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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