

### III. ESSAYS AND REVIEWS

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## The Concept of Technological Modes/ Paradigms: Introduction

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#### **Abstract**

*The history of long cycles is closely related to the emergence, development and change of the so-called technological modes or paradigms, which are a system of leading at that time technologies and ways of their application. There are theories, according to which, the most important explanation of the nature and pulsation of K-waves is the change of technological modes and / or techno-economic paradigms. Though it is not quite correct, but the rhythm of technological paradigm shift can be traced in each K-wave. Some ideas about the interconnection between K-waves and techno-economic paradigms are presented in the paper.*

**Keywords:** *technological modes, technological paradigms, long cycles, Kondratieff waves, textile industry, railway lines, coal, steel, electricity, chemical industry, heavy engineering, automobile manufacturing, man-made materials, electronics, microelectronics, personal computers, biotechnologies, nanotechnology, robotics, cognitive sciences, self-regulating system.*

As is known, the concept of long economic cycles with a duration of 50–60 years was formulated in the works of N. D. Kondratieff in the 1920s (see Kondratieff 1928, 1935). Later these cycles became known as long cycles or Kondratieff waves (Schumpeter 1939).

One should mention that Kondratieff showed that in the long-term dynamics (50–60 years) there is a certain cyclical regularity, that is, on a long historical interval, starting from the end of the 18<sup>th</sup> century one can distinguish recurring long (with duration of 40–60 years) economic cycles. At the same time in each long cycle there are two phases that are approximately equal in duration:

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upward and downward (each lasting 20–30 years). Accordingly, during the upward phase there is a growth of some important economic indicators (including prices, *i.e.* there was inflation), and during the downward phase – their absolute or relative decline. These long cycles were called Kondratieff waves. During the upward phase of the Kondratieff wave, the rapid economic expansion inevitably leads society to the need for change. But the possibilities of societal transformation lag behind the demands of the economy.

The history of long cycles is closely related to the emergence, development and change of the so-called technological modes or paradigms, which are a system of leading at that time technologies and ways of their application. Thus, N. D. Kondratieff suggested the idea that the alternation of the downward trend with the upward trend in the long waves is characterized by an active implementation of innovations (the so-called first empirical regularity [Kondratieff 2002 [1926]: 370–374]). Joseph A. Schumpeter (1939) conceptually developed this idea and considered uneven concentration of technological innovations as the main reason for long cycles (in his opinion, in the difficult conditions of depression, the innovative entrepreneurs more actively invest in the development and implementation of breakthrough innovations, which become the basis for the rise in the upward phase of the K-wave). Further, this innovative direction was transformed into theories, according to which, the most important explanation of the nature and pulsation of K-waves is the change of *technological modes* and / or *techno-economic paradigms*. Though it is not quite correct, but the rhythm of technological paradigm shift can be traced in each K-wave (about the role of investments and the change of these modes and paradigms see the explanation of the long-wave dynamics: Mensch 1979; Kleinknecht 1981, 1987; Dickson 1983; Dosi 1984; Freeman 1987; Tylecote 1992; Glazyev 1993; Mayevsky 1997; Modelski and Thompson 1996; Modelski 2001, 2006; Yakovets 2001; Freeman and Louçã 2001; Ayres 2006; Kleinknecht and van der Panne 2006; Dator 2006; Hirooka 2006; Papenhausen 2008; see also Lazurenko 1992; Glazyev 2009; Polterovich 2009; Perez 2002).<sup>1</sup>

When summarizing these, sometimes quite significant, approaches the main idea is as follows. Every subsequent K-wave is caused by the upsurge in the rate of basic technological innovations which arose during the downward phase of the preceding wave. Breakthrough innovations provide space for the expansion of production and cause an inflow of investments. The wave is uprising. As a result, new economic sectors are formed which create a new technological paradigm. The latter ultimately restructures the whole economy and

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<sup>1</sup> Different researchers may give different attributes to the modes and paradigms (*e.g.*, *techno-economic modes* and *technological paradigms*). Sometimes these concepts are used as synonyms, and sometimes as complementary definitions. The closest equivalent terms, such as a technological system and technological style can also be applied. In the articles presented in this section we use the term *technological paradigms*.

eventually creates a new techno-economic paradigm.<sup>2</sup> Since it takes a long time for the innovations to spread, and restructuring of economy needs time as well, this process takes up from 20 to 30 years. The downward phase is related to the fact that the efficiency of the previous cluster of basic innovations decreases and new breakthrough technologies and technologies of wide application lag behind. As a result, it takes another 20–30 years until the core of the new technological paradigm is formed and a new wave starts.

One can distinguish six paradigms (the sixth one is anticipated in the period from 2020 to the 2060/70s).<sup>3</sup> The summarized scheme of K-waves and corresponding technological paradigms is as follows:

- the first wave (1780 – the end of the 1840s): textile industry;
- the second wave (the end of 1840 – the 1890s): railway lines, coal, steel;
- the third wave (1890 – the end of the 1940s): electricity, chemical industry and heavy engineering;
- the fourth wave (the end of 1940s – the beginning of the 1980s): automobile manufacturing, man-made materials, electronics;
- the fifth wave (the beginning of the 1980s – ~ 2020): microelectronics, personal computers, biotechnologies;<sup>4</sup>
- the sixth wave (*c.* 2020 – the 2060/70s), according to some assumptions, will be mostly associated with nano- and biotechnologies, as well as alternative power sources and new information technologies (see, *e.g.*, Lynch 2004; Dator 2006).

<sup>2</sup> Developing the ideas of Carlota Perez (2002) one should note that besides the new equipment and production technologies the techno-economic paradigm includes a new system of management and business strategies and technologies, which is rooted not only among practicing businessmen, but also among economists as well as in broader strata of society. Therefore, one can assume that the mode is formed earlier and serves as the basis for the development of a paradigm. And when the changes begin to affect a number of aspects, economic consciousness and a way of doing in society are fundamentally reshaped. According to Perez (*Ibid.*), this means the final paradigm shift. Sometimes one can also speak about *the general purpose technologies* (Bresnahan and Trajtenberg 1995; Helpman 1998; for a detailed analysis of this theory, see Polterovich 2009). The meaning of this concept is close to the technological mode, but the meaning of the former concept is still narrower than the latter one, since there can be several general purpose technologies within one mode.

<sup>3</sup> See, *e.g.*, Schumpeter 1939; Freeman 1987; Rumyantseva 2003: 12–14; Glazyev 1993: 95–111; Ivanova 2003: 210; Papenhausen 2008: 789; Akayev *et al.* 2012. In fact, as in any classification there are numerous differences in the main characteristics of some or other modes, *e.g.*, some researchers ‘attribute’ such transitional areas of innovations like automobile to the third wave, the others – to the fourth K-wave, *etc.* (see also the note below).

<sup>4</sup> Alternatively, the following definitions are used: for the third Kondratieff wave ‘the age of steel, electricity, and heavy engineering’; for the fourth wave ‘the age of oil, automobile and mass production’. Finally, the current fifth wave is described as ‘the age of information and telecommunications’ (Papenhausen 2008: 789). This is not surprising, since the life cycle of a new technological paradigm does not fit into one phase of the production principle (*e.g.*, heavy engineering developed since the 1830s and accompanied the whole Industrial production principle). The question, therefore, is at what phase this sector becomes an innovative leader.

However, in our opinion, this paradigm will be much broader and particularly related to biomedical innovations. We suppose that during the final phase of the Cybernetic Revolution different *developmental trends will produce a system cluster of innovations as is often the case with the innovative phases of production revolutions*. Thus, as for the forecasts for the final phase of the Cybernetic Revolution we assume that *the general drivers of the final phase of the Cybernetic Revolution will be medicine, additive (3D printers), nano- and bio technologies, robotics, IT, cognitive sciences*, which together will form a *sophisticated system of self-regulating production*. We denote this complex as **MANBRIC-technologies** (see Grinin L., and Grinin A. 2015, 2016, 2020a, 2020b; Grinin, Grinin, and Korotayev 2017, 2020, 2022).

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