

Chapter 2

Kondratieff Waves in the World System Perspective

This chapter offers an historical and theoretical analysis of K-wave dynamics within the World System framework; in particular, it studies the influence of long wave dynamics on the changes of the world GDP growth rates during the last two centuries. This chapter concludes with a section that presents an hypothesis that the change of K-wave upswing and downswing phases correlates significantly with the phases of fluctuations in the relationships between the World System Core and Periphery, as well as with changes in the World System Core.

As we have already mentioned above, qualitative movement toward new unknown forms and levels cannot proceed infinitely because of inevitable limitations. As a result, such movement is accompanied by the emergence of disproportions as well as growth of competition for resources, etc. On the other hand, continuous human effort to overcome environmental resistance to such a movement has created conditions for the continuous emergence of more and more complex and effective structures at the level of both individual societies and the World System as a whole. However, relatively short periods of fast development gave place to periods of stagnation, crisis, and sometimes even collapse. This was one of the main causes that led to the formation of cyclical components of social macrodynamics that in the pre-industrial epoch could include cycles with many different periods, including secular and even millennial ones (e.g., Korotayev & Khaltourina, 2006; Korotayev, Malkov, & Khaltourina, 2006a, 2006b; Коротаев et al., 2010; Nefedov, 2004; Гринин и Коротаев, 2012; Turchin, 2003, 2005a, 2005b; Turchin & Korotayev, 2006; Turchin & Nefedov, 2009).

As we said in *Chap. 1*, in the industrial period we see the emergence of new cyclical components including Juglar cycles with a characteristic period between 7 and 11 years that manifest themselves in energetic booms and crises that suddenly

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engulf social systems. At the same time cyclical dynamics in industrial societies is represented by cycles with a characteristic period of 40 to 60 years known as Kondratieff waves (or just K-waves).

In this chapter we will analyze the emergence of K-waves in the World System economic dynamics in the nineteenth century and the changes that can be traced within K-wave patterns in the twentieth century, but especially after the Second World War. We will also analyze the peculiarities of the study of K-waves within the World System scale and will demonstrate that an adequate understanding of the nature of the modern K-wave dynamics can only be achieved if this phenomenon is studied precisely within this framework.

Long Waves in the World Economic Dynamics

As it has been already said, in the 1920s Nikolai Kondratieff observed that the historical record of some economic indicators then available to him appeared to indicate a cyclic regularity of phases of gradual increases in the values of these respective indicators followed by phases of decline and produced a systematic analysis of these data (Kondratieff, 2004 [1922]: Chap. 5, 1935 [1925], 1926; Кондратьев, 1922: Chap. 5; 1925, 2002). The period of these apparent oscillations seemed to him to be around 50 years. This pattern was found by him with respect to such indicators as prices, interest rates, foreign trade, coal and pig iron production (as well as some other production indicators) for some major Western economies (first of all England, France, and the United States). Whereas the long waves in pig iron and coal production were claimed to be detected since the 1870s at the world level as well¹.

Kondratieff himself (in his seminal article “Long Cycles of Conjuncture” Кондратьев, 1925) mentioned the following scientists who had managed to detect before him to some degree these long waves of economic dynamics: Aftalion (1913), Layton (1922), Lescure (1907, 1912), Moore (1914, 1923), Motylev (Мотылев, 1923), Spiethoff (1925), and Trotsky (Троцкий, 1923); however, Trotsky was not sure that those waves could be regarded as a regular phenomenon (see Кондратьев, 1993a: 27–29). He also mentioned a number of economists who refused to identify long waves as a regular phenomenon, but actively discussed them, such as Cassel (1918), Kautsky (Каутский 1918), Osinsky (Осинский, 1923a, 1923b) (*Ibidem*: 29). In his study “Dynamics of prices of manufactured and

¹ Note that as regards the production indices during decline/downswing phases we are dealing with the slowdown of the growth of production rather than with actual declines in production that rarely last longer than 1–2 years, whereas during the upswing phase we are dealing with a general acceleration of production growth rates in comparison with the preceding downswing/slowdown period (see, e.g., Modelski 2001, 2006 who prefers quite logically to designate ‘decline/downswing’ phases as ‘phases of take-off’, whereas the upswing phases are denoted by him as ‘high growth phases’).

agricultural commodities” published in 1928 (Кондратьев, 2002: 450–451) Kondratieff provided an even larger list of economists who noticed the long wave phenomenon.

Among important Kondratieff predecessors one should also mention J. van Gelderen (1913), M. A. Bunyatyan (Бунятян 1915), and S. de Wolff (1924). One can also mention William Henry Beveridge (better known, perhaps, as Lord Beveridge, the author of the so-called Beveridge Report on Social Insurance and Allied Services of 1942 that served after the Second World War as the basis for the British Welfare State, especially the National Health Service), who discovered a number of cycles in the long-term dynamics of wheat prices, whereas one of those cycles turned to have an average periodicity of 54 years (Beveridge, 1921, 1922).

In any case, it is clear that long waves started to be mentioned quite frequently in the 1900s, but starting from the 1920s they began to be mentioned especially actively. One of Kondratieff’s teachers, Tugan-Baranovsky also mentioned them, in particular in his study “Paper Money and Metal” (Туған-Барановский, 1998 [1917]). However, none of the abovementioned economists had studied the long waves systematically, and none of them offered a systematic theory of the long cycles. Thus, the real contribution of Kondratieff was not the discovery of the long wave phenomenon as is frequently believed, but the systematic study of this phenomenon and the development of a long wave theory on this basis.

In many respects Kondratieff’s discovery can well be compared with Edwin Hubble’s discovery of the expanding Universe that was made also in the 1920s. Let us recollect that the redshift phenomenon had been known long before the seminal work of Hubble. But it was Hubble who was able to produce a systematic theory of the expanding Universe on the basis of the systematic analysis of the redshift data. Similarly, the long wave phenomenon in economic dynamics had been known well before Kondratieff, but it was Kondratieff who was able to produce a systematic theory of the long cycles of global dynamics on the basis of a systematic analysis of scattered observations of long waves within the economic dynamics of various countries.

Kondratieff himself identified the following long waves and their phases (see Table 2.1).

The subsequent students of Kondratieff cycles identified additionally the following long-waves in the post-World War 1 period (see Table 2.2).

Table 2.1 Long waves and their phases identified by Kondratieff

Long wave number	Long wave phase	Dates of the beginning	Dates of the end
I	A: upswing	‘The end of the 1780s or beginning of the 1790s’	1810–1817
	B: downswing	1810–1817	1844–1851
II	A: upswing	1844–1851	1870–1875
	B: downswing	1870–1875	1890–1896
III	A: upswing	1890–1896	1914–1920
	B: downswing	1914–1920	

Table 2.2 ‘Post-Kondratieff’ long waves and their phases

Long wave number	Long wave phase	Dates of the beginning	Dates of the end
IV	A: upswing	1939–1950	1968–1974
	B: downswing	1968–1974	1984–1991
V	A: upswing	1984–1991	2006–2008
	B: downswing	2006–2008	the 2020s?

(*Sources*: Ayres, 2006; Бобровников, 2004: 47; Dickson, 1983; Goldstein, 1988: 67; Jourdon, 2008: 1040–1043; Linstone, 2006: Fig. 1; Mandel, 1980; Modelski & Thompson, 1996; Пантин и Лапкин, 2006: 283–285, 315; Tausch, 2006b: 101–104; Thompson, 2007: Table 5; Van Duijn, 1983: 155; Wallerstein, 1984. The last date is suggested by the authors of the present book. It was also suggested earlier by Lynch, 2004; Пантин и Лапкин, 2006: 315; see also Акаев, 2010; Акаев и Садовничий, 2010; Акаев, Fomin, Tsirel, & Korotayev, 2010; Акаев et al., 2011; about the forthcoming sixth wave see *Chaps. 5 and 6*).

A considerable number of explanations for the observed Kondratieff wave (or just K-wave Modelski, 2001; Modelski & Thompson, 1996) patterns have been proposed. From the initial stages of K-wave research, the respective K-wave pattern was detected in the most affirmative way with respect to price indices (see below). Most explanations proposed during this period were monetary, or monetary-related. For example, K-waves were connected with the inflation shocks caused by major wars (e.g., Åkerman, 1932; Bernstein, 1940; Silberling, 1943, etc.). In recent decades such explanations went out of fashion, as the K-wave pattern stopped being traced in the price indices after the Second World War (e.g., Бобровников, 2004: 54; Goldstein, 1988: 75).

Kondratieff himself accounted for K-wave dynamics first of all on the basis of capital investment dynamics (see Kondratieff, 1928, 1984; Кондратьев, 2002: 387–397). This line was further developed by Jay W. Forrester and his colleagues (see, e.g., Forrester, 1978, 1981, 1985; Senge, 1982 etc.), as well as by A. van der Zwan (1980), Hans Glismann, Horst Rodemer, and Frank Wolter (1983) etc.

However, in the recent decades the most popular explanation of K-wave dynamics was the one connecting them with the waves of technological innovations.

Kondratieff himself noticed that ‘during the recession of the long waves an especially large number of important discoveries and inventions in the technique of production and communication are made, which, however, are usually applied on a large scale only at the beginning of the next long upswing’ (Kondratieff, 1935: 111, see also, e.g., Кондратьев, 2002: 370–374).

This direction of reasoning was used by Schumpeter (1939) to develop a rather influential ‘cluster-of-innovation’ version of K-waves’ theory, according to which Kondratieff cycles were predicated primarily on discontinuous rates of innovation (for more recent developments of the Schumpeterian version of K-wave theory see, e.g., Ayres, 2006; Berry, 1991; Dator, 2006; Devezas and Modelski, 2003; Dickson,

1983; Freeman, 1987; Hirooka, 2006; Маевский, 1997; Mensch, 1979; Modelski and Thompson, 1996; Modelski, 2001, 2006; Papenhausen, 2008; Perez, 2011; Яковец, 2001; Tylecote, 1992; Глазьев, 1993) for the most recent presentation of empirical evidence in support of Schumpeter's cluster-of-innovation hypothesis see Kleinknecht & van der Panne, 2006; Коротаев и Гринин (2013). Within this approach every Kondratieff wave is associated with a certain leading sector (or leading sectors), technological system(s) or technological style(s). For example, the third Kondratieff wave is sometimes characterized as 'the age of steel, electricity, and heavy engineering. The fourth wave takes in the age of oil, the automobile and mass production. Finally, the current fifth wave is described as the age of information and telecommunications' (Papenhausen, 2008: 789); whereas the forthcoming sixth wave is sometimes supposed to be connected first of all with nano- and biotechnologies (e.g., Акаев, 2010, 2011; Dator, 2006; Lynch, 2004; Прайд и Коротаев, 2008; for a detailed analysis of the possible technological basis of the sixth K-wave see *Chaps. 5 and 6* below).

There were also a number of attempts to combine capital investment and innovation theories of K-waves (e.g., Акаев, 2010; Rostow, 1975, 1978; van Duijn, 1979, 1981, 1983 etc.). Of special interest is the Devezas–Corredine model based on biological determinants (generations and learning rate) and information theory that explains (for the first time) the characteristic period (50–60 years) of Kondratieff cycles (Devezas & Corredine, 2001, 2002; see also Devezas, Linstone, & Santos, 2005).

Many social scientists consider Kondratieff waves as a very important component of modern world-system dynamics. As has been phrased by one of the most important K-wave students,

long waves of economic growth possess a very strong claim to major significance in the social processes of the world system... Long waves of technological change, roughly 40–60 years in duration, help shape many important processes... They have become increasingly influential over the past thousand years. K-waves have become especially critical to an understanding of economic growth, wars, and systemic leadership... But they also appear to be important to other processes such as domestic political change, culture, and generational change. This list may not exhaust the significance of Kondratieff waves but it should help establish an argument for the importance of long waves to the world's set of social processes (Thompson, 2007).

Against this background it appears rather significant that evidence of the very presence of the Kondratieff waves in the world dynamics remains quite controversial. The presence of K-waves in price dynamics (at least till the Second World War) has found very wide empirical support (see, e.g., Cleary & Hobbs, 1983; Gordon, 1978: 24; van Ewijk, 1982 etc.). However, as has been mentioned above, the K-wave pattern stopped being traced in the price indices after the Second World War (e.g., Бобровников, 2004: 54; Goldstein, 1988: 75).

On the other hand, as has already been demonstrated (Щеглов, 2009; Гринин, Коротаев, и Цирель, 2011: 75–77), when inflation is taken into account, and the price indices are expressed in grams of gold rather than in dollars, those indices continue to correspond to the K-wave pattern (see Fig. 2.1). Starting from the early

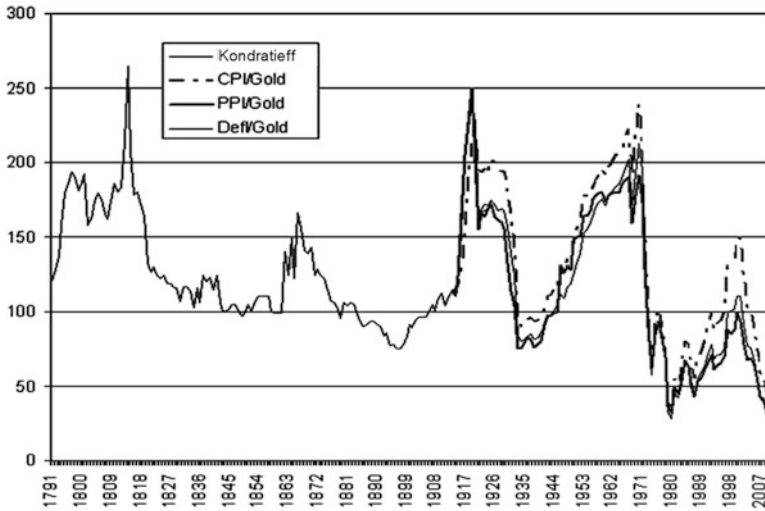


Fig. 2.1 The USA producer price index used by Kondratieff and extended to 2010 in the gold equivalent (100=1900–1910 level). *Sources:* (Щеглов, 2009; Гринин, Коротаев и Цирель, 2011: 76)

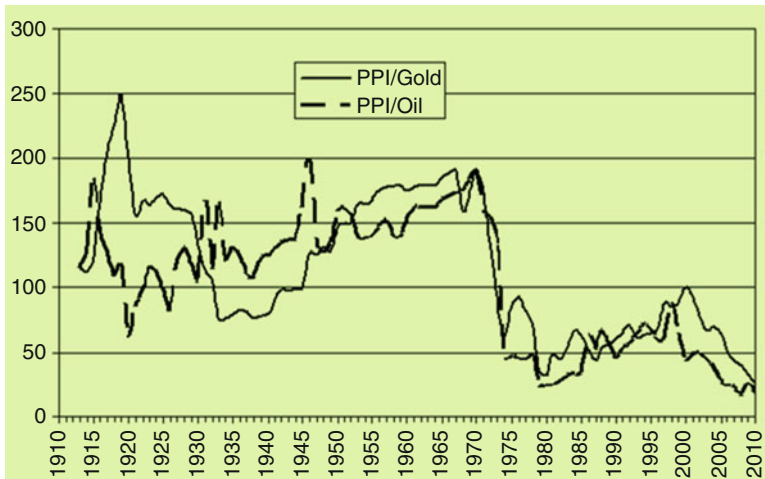


Fig. 2.2 The USA producer price index in gold and oil equivalent (100=1900–1910 level). *Sources:* (BP 2010; Щеглов, 2009; Гринин, Коротаев, и Цирель, 2011: 77)

1970s, energy resources (and, first of all, oil) served as a sort of ‘reserve currency’ comparable with gold, and the Kondratieff waves started to be traced in the price index dynamics when expressed in oil equivalent (see Fig. 2.2).

How Real are Kondratieff Waves? Discussions and Empirical Evidence

Regarding long waves in production dynamics, we will restrict ourselves to analyzing evidence for the presence of K-waves in world production indices. As Kondratieff waves tend to be considered an important component of the World System social and economic dynamics, one would expect to detect them with respect to the major world macroeconomic indicators; first of all with respect to the world GDP dynamics (Chase-Dunn & Grimes, 1995: 405–411). However, till now attempts to detect them in the world GDP (or similar indicators') dynamics record have brought controversial results.

Kondratieff himself claimed to have detected long waves in the dynamics of the world production of coal and pig iron (e.g., Kondratieff, 1935: 109–110). However, his evidence of the presence of long waves in these series (as well as in all the production dynamics series on national levels) was criticized most sharply:

Foremost among the methodological criticisms have been those directed against Kondratieff's use of trend curves. Kondratieff's method is first to fit a long-term trend to a series and then to use moving averages to bring out long waves in the residuals (the fluctuations around the trend curve).

But 'when he eliminated the trend, Kondratieff failed to formulate clearly what the trend stands for' (Garvy, 1943: 209). The equations Kondratieff uses for these long-term trend curves... include rather elaborate (often cubic) functions.² This casts doubt on the theoretical meaning and parsimony of the resulting long waves, which cannot be seen as simple variations in production growth rates (Goldstein, 1988: 82; see also, e.g., Barr, 1979: 704; Eklund, 1980: 398–399, etc.).

However, quite a few scientists presented later new evidence supporting the presence of long waves in the dynamics of the world economic indicators. For example, Mandel (1975: 141; 1980: 3) demonstrated that, in full accordance with Kondratieff's theory, between 1820 and 1967 during the A Phases of K-cycles, the annual compound growth rates in world trade were on average significantly higher than in adjacent Phases B. Similar results were arrived at by David M. Gordon (1978: 24) with respect to world *per capita* production for 1865–1938 based on world production data from Dupriez (1947, 2: 567), world industrial dynamics (for 1830–1980) taken from Thomas Kuczynski (1982: 28), and average growth rates of the world economy (Kuczynski, 1978: 86) for 1850–1977; similar results were obtained by Joshua Goldstein (1988: 211–217).

Of special interest are the works by Marchetti and his co-workers at the International Institute for Advanced System Analysis who have shown extensively the evidence of K-waves using physical indicators, as for instance energy consumption, transportation systems dynamics, etc. (Marchetti, 1980, 1986, 1988 etc.). However, empirical tests produced by a few other scholars failed to support the hypothesis of the K-waves' presence in world production dynamics (see, e.g., Chase-Dunn & Grimes, 1995: 407–409; van der Zwan, 1980: 192–197, reporting the results of Peter Grimes' research).

²For example, for the trend of English lead production the function used by Kondratieff looks as follows: $y = 10^{(0.0278 - 0.0166x - 0.00012x^2)}$.

There were a few attempts to apply spectral analysis in order to detect the presence of K-waves in the world production dynamics. Thomas Kuczynski (1978) applied spectral analysis in order to detect K-waves in world agricultural production, total exports, inventions, innovations, industrial production, and total production for the period between 1850 and 1976. Though Kuczynski suggests that his results ‘seem to corroborate’ the K-wave hypothesis, he himself does not find this support decisive and admits that ‘we cannot exclude the possibility that the 60-year-cycle... is a random cycle’ (1978: 81–82); note that Kuczynski did not make any formal test of statistical significance of these K-waves tentatively identified by his spectral analysis. K-waves were also claimed to have been found with spectral analysis by Rainer Metz (1992) both in the GDP production series of eight European countries (for the 1850–1979 period) and in the world production index developed by Hans Bieshaar and Alfred Kleinknecht (1984) for 1780–1979; however, later he denounced those findings (Metz, 1998, 2006).

A few scientists using spectral analysis have failed to detect K-waves in production series on the national levels of quite a few countries (e.g., Diebolt & Doliger, 2006; Metz, 1998, 2006; van Ewijk, 1982 see *Chap. 4* and *Appendix B* below for more detail).

Against this background we (together with Sergey Tsirel) have found it appropriate to check the presence of K-waves in the world GDP dynamics using the most recent datasets on these variable dynamics covering the period between 1870 and 2007 (Maddison, 1995, 2001, 2003, 2010; World Bank, 2016) and applying an upgraded methodology for the estimation of statistical significance of detected waves (see, e.g., Korotayev & Tsirel, 2010, Коротаев и Цирель, 2010а, 2010б; Гринин, Коротаев и Цирель, 2011); it is worth stressing that for the first time our analysis made it possible to estimate the statistical significance of Kondratieff waves in the world GDP dynamics; we have demonstrated the presence of K-waves in the world GDP dynamics at a generally quite acceptable 5% level. We will return later to the issue of Kondratieff wave detection using spectral analysis methods below in *Chap. 4* and *Appendix B*.

Kondratieff Waves in the Post-World War II GDP Data

Note that the Kondratieff-wave component can be seen quite clearly in the post-World War II dynamics of the world GDP growth rates quite directly, and without the application of any special statistical techniques (see Fig. 2.3)³:

³Note that for recent decades K-waves (as well as Juglar cycles) are also quite visible in the world dynamics of such important macroeconomic variables as the world gross fixed capital formation (as % of GDP) and the investment effectiveness (it indicates how many dollars of the world GDP growth is achieved with one dollar investments)—see online [Appendix](#) to this chapter, Figs. [S1](#) and [S2](#). The dynamics of both variables are connected to the world GDP dynamics. Actually, the world GDP dynamics is determined to a considerable extent by the dynamics of those two variables.

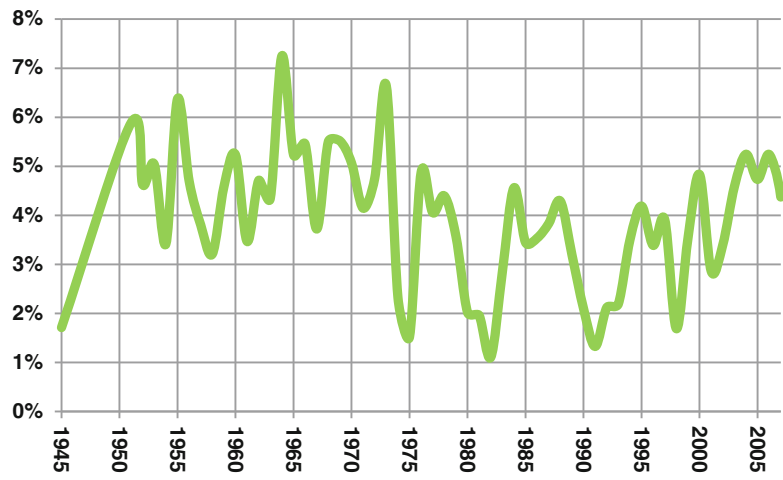


Fig. 2.3 Dynamics of the Annual World GDP Growth Rates (%), 1945–2007; 1945 point corresponds to the average annual growth rate in the 1940s. *Initial series:* Maddison/World Bank empirical estimates

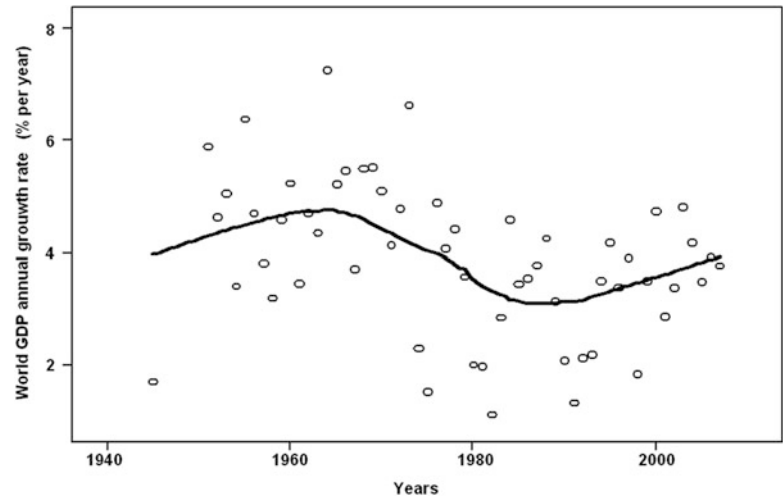


Fig. 2.4 Maddison/World Bank empirical estimates with fitted LOWESS line. Kernel: Triweight. % of points to fit: 50

However, the Kondratieff wave component becomes especially visible if a LOWESS (=LOcally WEighted Scatterplot Smoothing) line is fitted (see Fig. 2.4).

As can be seen, Figs 2.3, and 2.4 indicate:

1. That the Kondratieff-wave pattern can be detected up to the present in a surprisingly intact form (though, possibly, with a certain shortening of its period, suggested by a few authors [see, e.g., Бобровников, 2004; Tausch, 2006a; ПАНТИН и ЛАПКИН, 2006; van der Zwan, 1980]).
2. That the present world financial-economic crisis might indeed mark the beginning of a new Kondratieff Phase B (downswing see also Table 2.2 above). Indeed, consider the post-World War II dynamics of the world GDP growth rates taking into account the 2008–2014 period (see Fig. 2.5).

As we see, according to its magnitude the 2008–2009 global financial-economic crisis does not appear to resemble a usual crisis marking the end of a Juglar cycle amidst an upswing (or even downswing) phase of a Kondratieff cycle. Instead it resembles particularly deep crises (similar to the ones of 1973–1974, 1929–1933, mid 1870s or mid 1820s) that are found just at the border of phases A and B of the K-waves (see, e.g., Grinin & Korotayev, 2010a, 2010b).

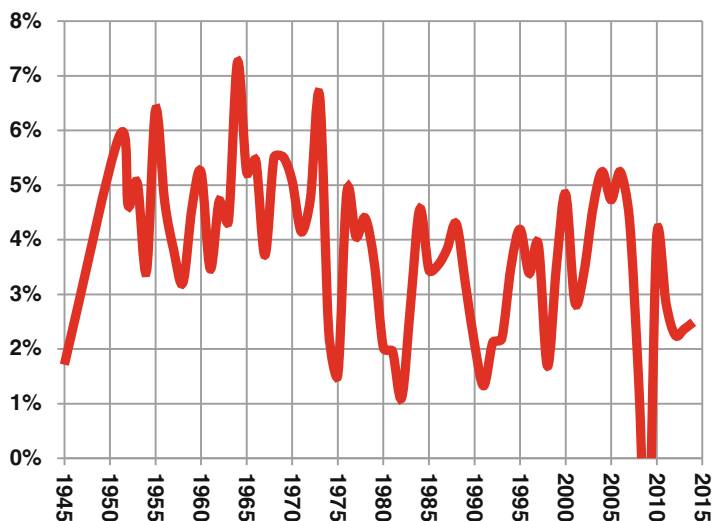


Fig. 2.5 Dynamics of the Annual World GDP Growth Rates (%), 1945–2014. *Sources:* (World Bank, 2016; NY.GDP.MKTP.PP.KD; Maddison, 2010; Conference Board, 2016)

Kondratieff Waves in the Pre-1945/50 World GDP Data

As can be seen in Fig. 2.6, for the 1870–1945/50 period the K-wave pattern is not as easily visible as after 1945/50. The turbulent 2nd, 3rd and 4th decades of the twentieth century are characterized by an enormous magnitude of fluctuations of world GDP growth rates (not observed either in the previous or subsequent periods).

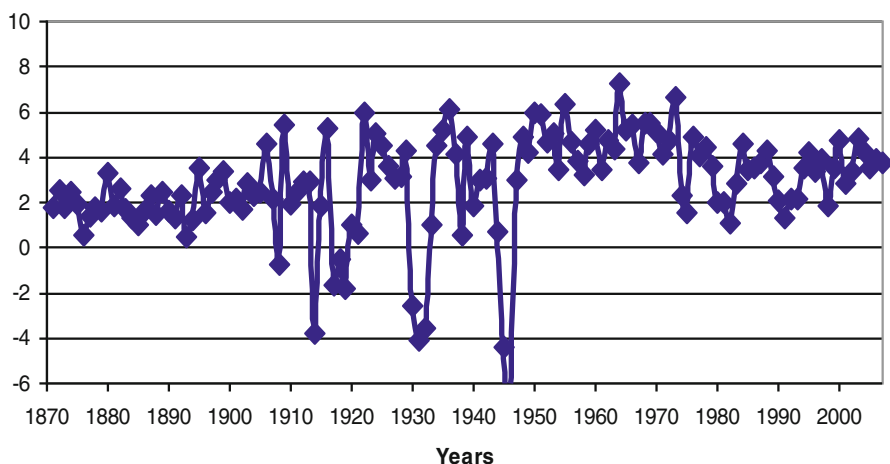


Fig. 2.6 Dynamics of the World GDP Annual Growth Rates (%), 1871–2007. *Source:* (Korotayev and Tsirel, 2010: 6)

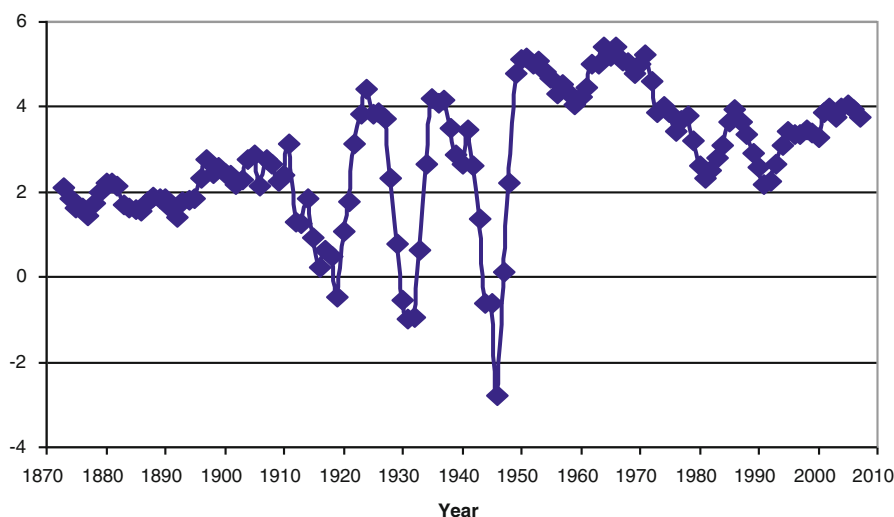


Fig. 2.7 Dynamics of the World GDP annual growth rates (%), moving 5-year averages, 1871–2007. *Sources:* World Bank, 2016; Maddison, 2010. *Note:* 1873 point corresponds to the average annual growth rate in 1871–1875, 1874 to 1872–1876, 1875 to 1873–1877... 2005 to 2003–2007; 2006 and 2007 points correspond to the annual growth rates in years 2006 and 2007 respectively

The lowest (for 1871–2007) figures of the world GDP annual rates of change are observed just in these decades (during the Great Depression, World Wars I and II as well as immediately after the end of those wars). On the other hand, during the mid-20s and mid-30s booms, the world GDP annual growth rates achieved historical maximums (they were only exceeded during the K-wave 4 Phase A, in the 1950s and 1960s, and were generally higher than during both the pre-World War I and recent [1990s and 2000s] upswings). This, of course, complicates the detection of the long-wave pattern during those decades.

Actually, this pattern is somehow more visible in the diagrams for 5-year moving averages, and, especially, for simple 5-year averages (see Figs 2.7 and 2.8):

The application of the LOWESS technique reveals a specific K-wave pattern in the pre-1950 series (see Fig. 2.9):

In fact, the LOWESS technique reveals quite clearly the K-wave pattern prior to World War I (in the period corresponding to Phase B of the second Kondratieff wave and major part of Phase A of the third wave) (see Fig. 2.10).

However, the third K-wave (apparently strongly deformed by World War I) looks much less clear (see Fig. 2.11).

The main problem is presented by Phase B of the third Kondratieff cycle—as the timing of its start remains unclear (1914, or mid-1920s?). Our analysis does not make it possible to choose explicitly between two options—either that the K3 Phase B started in 1914 and was interrupted by the mid-1920s boom; or that the K3 Phase A continued until the mid-1920s, having been interrupted by the WWI bust.

However, the LOWESS technique produces an especially neat K-wave pattern with the second assumption—that is that it materializes when we omit the WWI influence (see Fig. 2.12).

This figure reveals rather distinctly the double peaks of the upswings. With a stronger smoothing (see Fig. 2.13) the form of the peaks becomes smoother, and as well the waves themselves become more distinct.

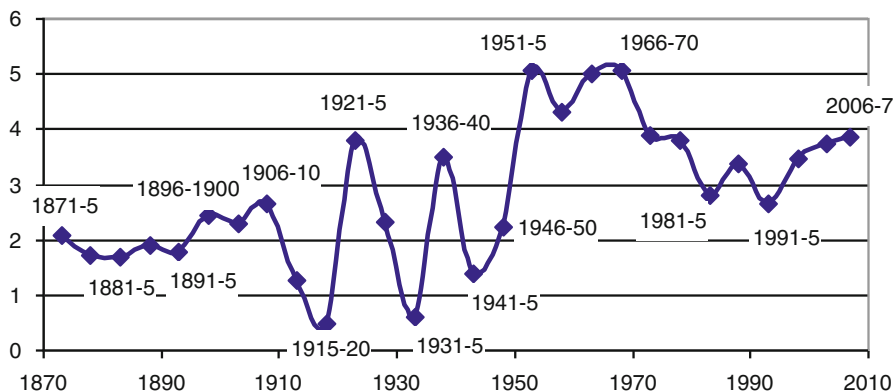


Fig. 2.8 Dynamics of the World GDP annual growth rates (%), 5-year averages, 1871–2007. Sources: (World Bank, 2016; Maddison, 2010)

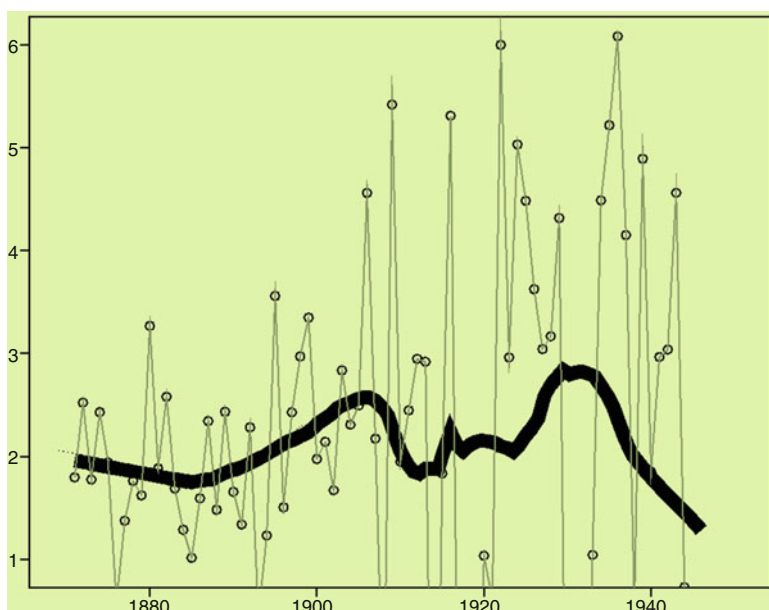


Fig. 2.9 World GDP annual growth rate dynamics, % per year (1870–1946): Maddison empirical estimates with fitted LOWESS line. *Note:* Maddison-based empirical estimates with fitted LOWESS line. Kernel: Triweight. % of points to fit: 40

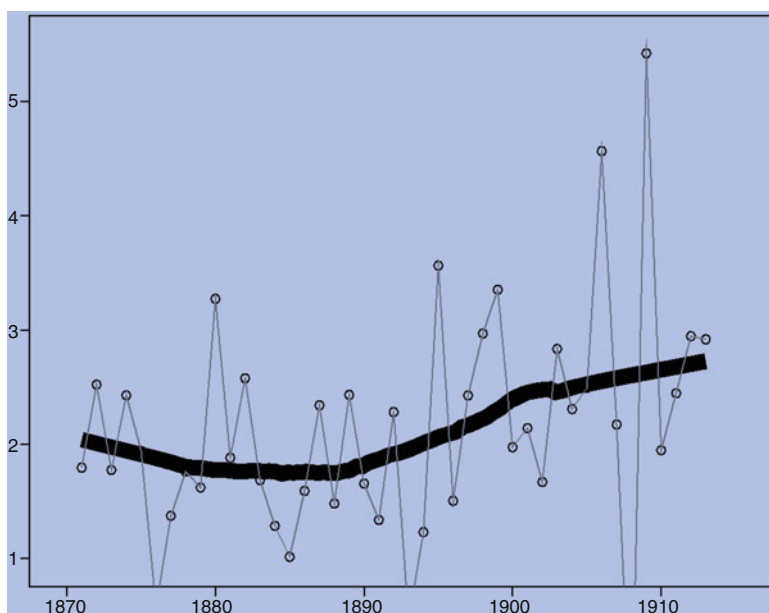


Fig. 2.10 World GDP annual growth rate dynamics, % per year: Maddison-based empirical estimates with fitted LOWESS line. **Phase B (Downswing) of the Second Kondratieff Wave and Phase A (Upswing) of the Third Wave, 1871–1913.** *Note:* Maddison-based empirical estimates with fitted LOWESS line. Kernel: Triweight. % of points to fit: 50

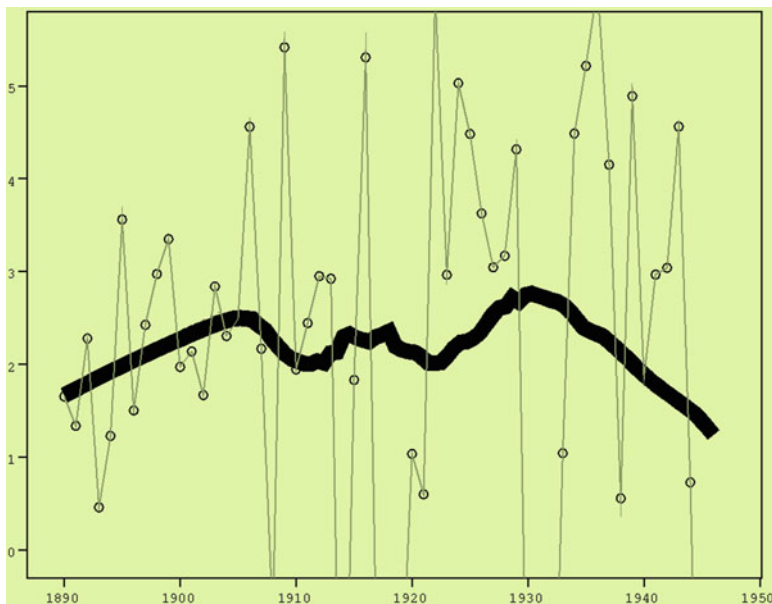


Fig. 2.11 World GDP annual growth rate dynamics: Maddison-based empirical estimates with fitted LOWESS line. **The Third Kondratieff Wave.** *Note:* Maddison-based empirical estimates with fitted LOWESS line. Kernel: Triweight. % of points to fit: 60

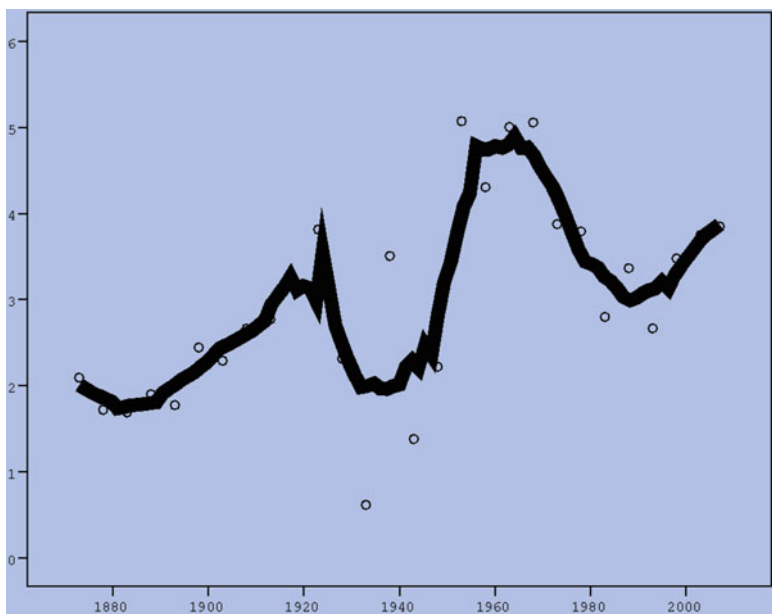


Fig. 2.12 World GDP annual growth rate dynamics, % per year, **5-year averages**: Maddison-based empirical estimates with fitted LOWESS line. **1870–2007, omitting World War I influence.** *Note:* Maddison-based empirical estimates with fitted LOWESS line. Kernel: Triweight. % of points to fit: 20

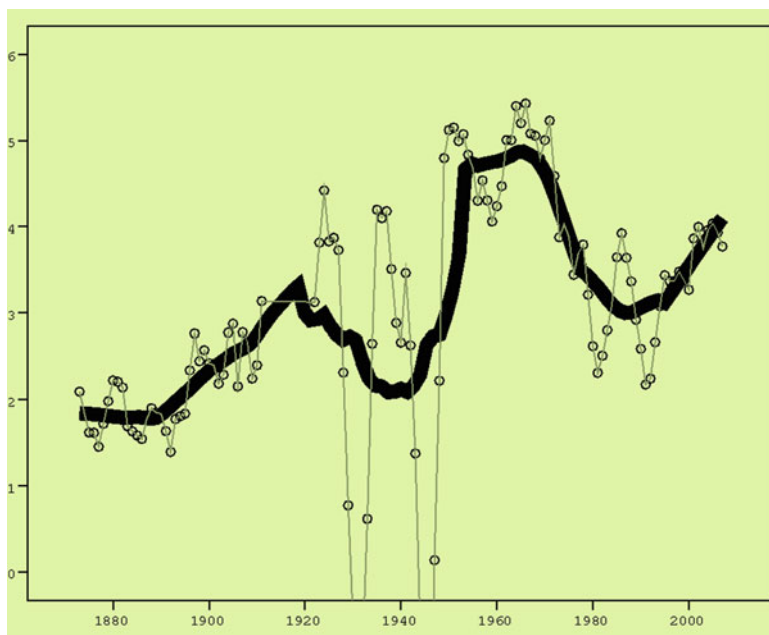


Fig. 2.13 World GDP annual growth rate dynamics, **5-year moving average**: Maddison-based empirical estimates with fitted LOWESS line. **1870–2007, omitting World War I influence.** *Note:* Maddison-based empirical estimates with fitted LOWESS line. Kernel: Triweight. % of points to fit: 20

Hence, it looks a bit more likely that K3 Phase A lasted until the mid-1920s (having been interrupted by WWI). Incidentally, if we take the WWI years of influence (1914–1921) out, we arrive at a quite reasonable K3 Phase A length—26 years, even if we take 1929 as the end of this phase:

$$1929 - 1895 = 34$$

$$34 - 8 = 26$$

Note that with the first assumption (K3 Phase B started in 1914 and was interrupted by the mid-1920s boom) we would have an excessive length of K3 Phase B—32 years (that would, however, become quite normal, if we take out the mid-1920s boom years).

Yet, it seems necessary to stress that we find overall additional support for the Kondratieff pattern in the world GDP dynamics data for the 1870–1950 period. First of all, this is manifested by the fact that both Phases A of this period have relatively higher rates of world GDP growth, whereas both Phases B are characterized by relatively lower rates. Note that this holds true without taking out either the effect of World War I, or the effect of the 1920s boom influence, and this is irrespective

Table 2.3 Average annual World GDP growth rates (%) during phases A and B of Kondratieff waves, 1871–2007

Kondratieff wave number	Phase	Years		Average annual World GDP growth rates (%) during respective phase	
		Version 1	Version 2	Version 1	Version 2
II	End of Phase A	1871–1875	1871–1875	2.09	2.09
II	B	1876–1894	1876–1894	1.68	1.68
III	A	1895–1913	1895–1929	2.57	2.34
III	B	1914–1946	1930–1946	1.50	0.98
IV	A	1947–1973	1947–1973	4.84	4.84
IV	B	1974–1991	1974–1983	3.05	2.88
V	A	1992–2007	1984–2007	3.49	3.42

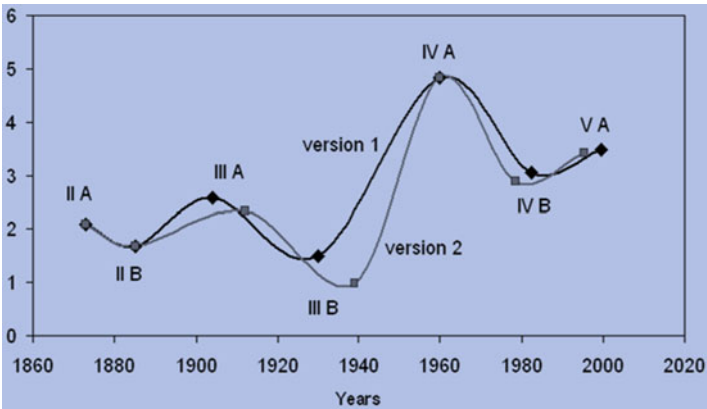


Fig. 2.14 Average annual World GDP growth rates (%) during phases A and B of Kondratieff waves, 1871–2007

of whatever dating for the beginnings and ends of the relevant phases we choose (see Table 2.3 and Fig. 2.14).

With different dates for the beginnings and ends of various phases we have understandably different shapes of long waves, but the overall Kondratieff wave pattern remains intact. Note that the difference between these two versions can be partly regarded as a continuation of the controversy between the following two approaches: (1) ‘the K-wave period is approximately constant in the last centuries’; (2) ‘the period of K-waves becomes shorter and shorter’).⁴

⁴See, e.g., Бобровников, 2004; Tausch, 2006a; Пантин и Лапкин, 2006; van der Zwan, 1980.

Kondratieff Waves in the Pre-1870 World GDP Dynamics

There are some grounds to doubt that Kondratieff waves can be traced back in the world GDP dynamics for the pre-1870 period (though for this period they appear to be detected for the GDP dynamics of the West).

Note that for the period between 1700 and 1870 Maddison provides world GDP estimates for one year only—for 1820. What is more, for the period before 1870 Maddison does not provide annual (or even per decade) estimates for many major economies, which makes it virtually impossible the construction of the world GDP annual (or even per decade) growth rates during this period. However, it appears possible to reconstruct a world GDP estimate for 1850, as for this year Maddison does provide his estimates for all the major economies. Thus, it appears possible to estimate the world GDP average annual growth rates for 1820–1850 (that is the period that more or less coincides with K1 Phase B) and for 1850–1870/1875 (that is K2 Phase A), and, consequently, to make a preliminary test as to whether the Kondratieff wave pattern can be observed for the 1820–1870 period **or not**.

The results look as follows (see Table 2.4):
Thus, whatever dating of the end of K2 Phase A we choose, we observe a rather strong deviation from the K-wave pattern. Indeed, according to this pattern one would expect that in the 1850–1870/5 period (corresponding to Phase A of the second Kondratieff wave) the World GDP average annual growth rate should be higher than in the subsequent period (corresponding to Phase B of this K-wave). However,

Table 2.4 Average annual World GDP growth rates (%) during phases A and B of Kondratieff waves, 1820–1894

Kondra- tieff wave number	Phase	Years		Average annual World GDP growth rates (%) during respective phase		Average annual World GDP growth rate predicted by Kondratieff wave pattern	Observed
		Version 1	Version 2	Version 1	Version 2		
I	B	1820– 1850	1820– 1850	0.88	0.88		
II	A	1851– 1875	1851– 1870	1.26	1.05	To be significantly higher than during the subsequent phase	Significantly lower than during the subsequent phase
II	B	1876– 1894	1871– 1894	1.68	1.76	To be significantly lower than during the subsequent phase	Significantly higher than during the subsequent phase

Table 2.5 Average annual World GDP growth rates (%) of the West during phases A and B of Kondratieff waves, 1820–1894

Kondratieff wave number	Phase	Years	Average annual World GDP growth rates (%) during respective phase	Average annual World GDP growth rate predicted by Kondratieff wave pattern	Observed
I	B	1820–1850	2.04	To be significantly lower than during the subsequent phase	Significantly lower than during the subsequent phase
II	A	1851–1875	2.45	To be significantly higher than during the subsequent phase	Significantly higher than during the subsequent phase
II	B	1876–1894	2.16	To be significantly lower than during the subsequent phase	Significantly lower than during the subsequent phase
III	A	1895–1913	2.94	To be significantly higher than during the previous phase	Significantly higher than during the previous phase

the actual situation turns out to be squarely the opposite—in 1870/75–1894 the World GDP average annual growth rate was significantly higher than in 1850–1870/75.

Note, however, that the K-wave pattern still seems to be observed for this period with respect to the GDP dynamics of the West⁵ (see Table 2.5 and Fig. 2.15).

Note: Data are for 12 major West European countries (Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom) and 4 ‘Western offshoots’ (the United States, Canada, Australia, New Zealand).

We believe that the fact that K-wave pattern can be traced backward in the GDP dynamics of the West for the pre-1870 period and that it is not found for the world GDP dynamics is not coincidental, and cannot be accounted for simply on the basis of the unreliability of the world GDP estimates for this period. In fact, it is not surprising that the Western GDP growth rates were generally higher in 1851–1875 than in 1876–1894, and the world growth rates were not. The proximate explanation is very simple. The world GDP growth rates in 1851–1875 were relatively low (in comparison with 1876–1894) mostly due to the enormous economic decline observed in China in 1852–1870 due to a social-demographic collapse in connection with the Taiping Rebellion and accompanying events of additional episodes of internal warfare, famines, epidemics, catastrophic inundations and so on (Непомнин,

⁵What is more, this pattern appears to be observed in the socio-economic dynamics of the European-centered world-system for a few centuries prior to 1820 (see, e.g., Beveridge, 1921, 1922; Goldstein, 1988; Jourdon, 2008; Modelski, 2006; Modelski & Thompson, 1996; Пантин и Лапкин, 2006; Thompson, 1988, 2007).

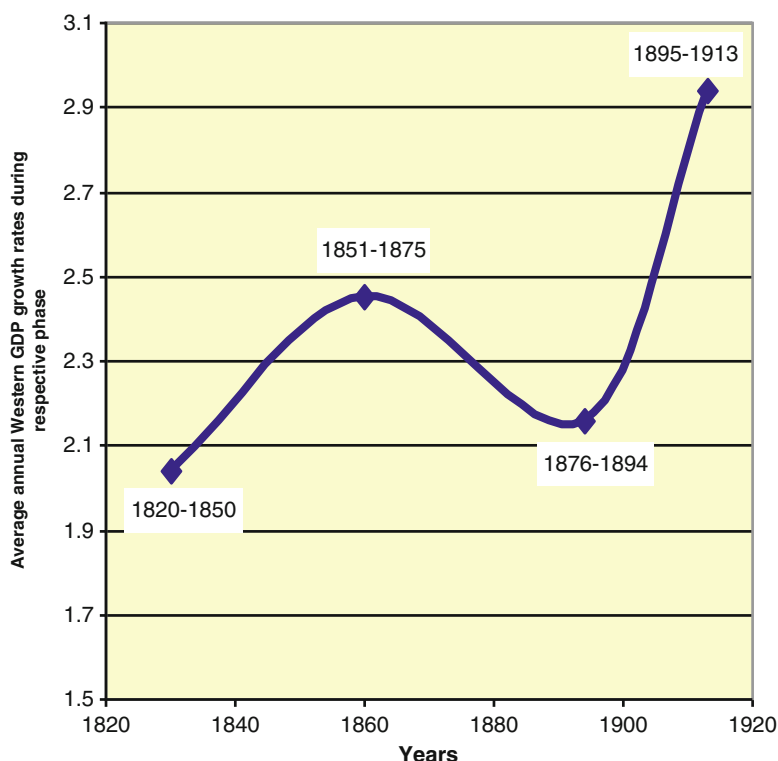


Fig. 2.15 Average annual World GDP growth rates (%) of the West during phases A and B of Kondratieff waves, 1820–1913

2005; Ларин, 1986; Kuhn, 1978; Liu, 1978; Илюшечкин, 1967; Perkins, 1969: 204 etc.) that resulted, for example, in the human death toll as high as 118 million human lives (Huang, 2002: 528). Note that in the mid-nineteenth century China was still a major world economic player, and the Chinese decline of that time affected the world GDP dynamics in a rather significant way. According to Maddison's estimates, in 1850 the Chinese GDP was about 247 billion international dollars (1990, PPP), as compared with about 63 billion in Great Britain, or 43 billion in the USA. By 1870, according to Maddison, it declined to less than \$190 billion, which compensated up to a very high degree for the acceleration of economic growth observed in the same years in the West (actually, Maddison appears to underestimate the magnitude of the Chinese economic decline in this period, so the actual influence of the Chinese 1852–1870 sociodemographic collapse might have been even more significant). The effects of K2 Phase A in the Western GDP dynamics started to be felt on the world level only at the very end of this phase, in 1871–1875, after the end of the collapse period in China and the beginning of the recovery of growth in this country.

In more general terms, it seems possible to maintain that in the pre-1870 epoch the Modern World System was not sufficiently integrated, and the World System core was not sufficiently strong yet—that is why the rhythm of the Western core's development was not quite realized on the world level. Only in the subsequent era does the World System reach such a level of integration and its core acquires such strength that it appears possible to trace quite securely Kondratieff waves in the World GDP dynamics.⁶

Kondratieff Waves in the World Technological Innovation Dynamics

Naturally, the connection between the K-waves and technological innovation processes deserves special attention. In order to re-test the Kondratieff–Schumpeter hypothesis about the presence of K-waves with regard to the world invention activities, we have used the World Intellectual Property Organization (WIPO) Statistics Database information on the number of patents granted annually in the world per one million of the world population in 1900–2008 (see Korotayev, Zinkina, & Borgevolnov, 2011 for more details). For 1985–2008 WIPO publishes direct data on the total number of patent grants in the world per year (WIPO 2012a). For the period, 1900–1985, we calculated this figure by summing up the data for all the countries (that are provided by the WIPO in a separate dataset WIPO, 2012b). We used as our sources of data on the world population dynamics the databases of Maddison (2010), UN Population Division (2016), and U.S. Bureau of the Census (2016).

The results of our calculations are presented in Fig. 2.16.

It is easy to see that the figure above reveals an unusually clear K-wave pattern (Note that a similar pattern has been detected in the dynamics of patent applications by Plakitkin (Плакиткин, 2011) who, however, did not appreciate that he was dealing with K-wave dynamics). In general, we see rather steady increases in the number of patent grants per million during K-wave A-phases ('upswings'), and we observe its rather pronounced declines during K-wave B-phases ('downswings'). Thus, the first period of the growth of the variable in question and revealed by

⁶The phenomenon that K-waves can be traced in Western economic dynamics earlier than at the world level has already been noticed by Reuveny and Thompson (2008) who provide the following explanation: if one takes the position that the core driver of K-waves is intermittent radical technological growth primarily originating in the system leader's economy, one would not expect world GDP to mirror K-wave shapes as well as the patterned fluctuations that are found in the lead economy and that world GDP might correspond more closely to the lead economy's fluctuations over time as the lead economy evolves into a more predominant central motor for the world economy. Reuveny and Thompson also argue that to the extent that technology drives long-term economic growth, the main problem (certainly not the only problem) in diffusing economic growth throughout the system is that the technology spreads unevenly. Most of it stays in the already affluent North and the rest fell farther behind the technological frontier. Up until recently very little trickled down to the global South (Reuveny & Thompson, 2001, 2004, 2008, 2009). Our findings also seem to match this interpretation.

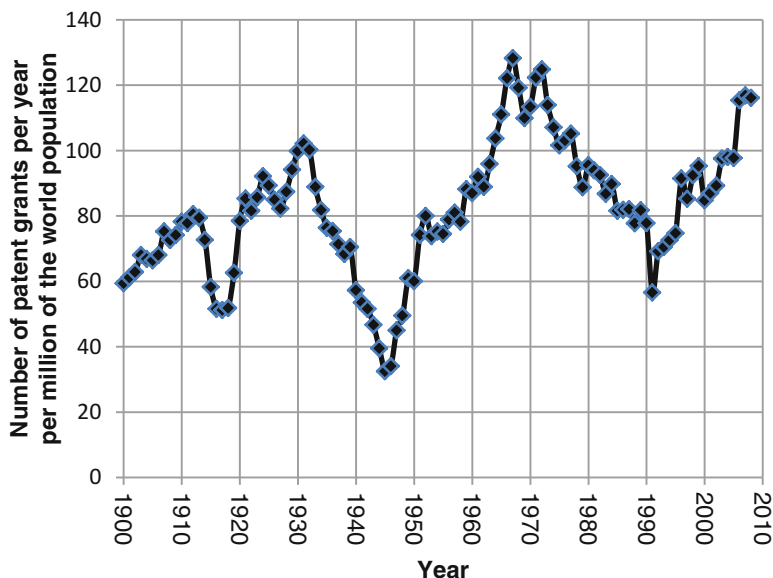


Fig. 2.16 Dynamics of number of patent grants per year per million of the world population, 1900–2008

Fig. 2.16 more or less coincided (with a rather slight, about 2–3 years, lag) with the A-phase of the third K-wave (1896–1929); it was only interrupted by the First World War when the number of patent grants per million experienced a precipitous but rather short decline—whereas after the war the value of the variable in question returned as quickly to the A-phase-specific trend line. The first prolonged period of the decline of the number of patent grants per million corresponds rather neatly (except for the above mentioned 2–3 year lag) to the B-phase of this wave (1929–1945); the second period of steady increase in the value of the variable in question correlates almost perfectly with the A-phase of the fourth K-wave (1945–1968/74), whereas the second period of decline corresponds rather well to its B-phase (1968/74–1984/1991); finally, the latest period of the growth of the number of patent grants per million correlates with the A-phase of the fifth K-wave.

Note, however, that this pattern apparently goes counter to the logic suggested by Kondratieff, Schumpeter and their followers who expected increases in invention activities during B-phases and decreases during A-phases. Yet, this contradiction is only apparent. Indeed, as we have mentioned above, Kondratieff maintained that ‘during the recession of the long waves, an especially large number of *important* discoveries and inventions in the technique of production and communication are made, which, however, are usually applied on a large scale only at the beginning of the next long upswing’ (Kondratieff, 1935: 111, our emphasis).

It has been suggested that it is necessary to distinguish between ‘breakthrough’ and ‘improving’ inventions (e.g., Akaev, 2010); breakthrough inventions are those that during a B-phase of a given K-wave create the foundations of a new technological system corresponding to a new K-wave. As suggested by Kondratieff, they find

their large-scale application during the A-phase of this new K-wave based on this new technological system, which is accompanied by a flood of improving innovations that are essential for the diffusion of technologies produced by breakthrough inventions made during the B-phase of the preceding K-wave (*Ibid.*; Hirooka, 2006). Thus, it appears important to distinguish between breakthrough inventions, which involve a paradigm shift, and innovations which represent improvements, adaptations, and modifications of the breakthrough inventions.

Note that of the total number of patents a negligible proportion has been granted for breakthrough inventions, whereas the overwhelming majority of all the inventions for which patents are granted are nothing else but ‘improving’ inventions. The exhaustion of the potential of a given K-wave’s technological system leads to a decrease of the number of inventions that actually realize the potential created by the breakthroughs which created the respective technological system. On the other hand, this very exhaustion of the previous technological system’s potential for improvement creates powerful stimuli for new paradigm shifting inventions. However, the increase in the number of breakthrough inventions in no way compensates the dramatic decrease of the number of innovations improving the potential of the previous technological system. Hence, on the basis of this logic there are theoretical grounds to expect that during the B-phases of K-waves the total number of inventions (and patent grants) per 1 million of population should decrease, whereas during A-phases we should observe a pronounced increase in this number (as some decrease in the number of breakthrough inventions is by far compensated by a dramatic increase in the number of improving inventions).

As we have seen, this pattern is what has been revealed by our test.

World System Effects and K-Wave Dynamics

As has already been mentioned above, adherents of the world-system approach consider K-waves as one of the most important components of the World System dynamics.

We quite agree with Thompson (2007), who maintains that K-waves may help to clarify many important points in World System processes. However, one could also trace another kind of logic—the analysis of the World System processes can contribute a lot to the clarification of the nature of the Kondratieff waves themselves. We believe that the driving forces of the K-waves can be adequately understood only if we take into account the dynamics, phases, and peculiarities of World System development. That is why we have tried to analyze K-waves on a World System scale. Clearly, such an approach can integrate different points of view on the nature of Kondratieff waves.

Actually, we can consider the following five points:

1. Kondratieff waves are most relevant when considered at the World System scale. As those waves always manifest themselves at supra-societal scales, the World System processes turn out to be very important for the understanding of the K-wave dynamics.

2. The expansion and intensification of the World System economic links lead to the formation of the preconditions for new upswings. Note that Kondratieff himself notice that ‘the new long cycles usually coincides with the expansion of the orbit of world economic ties’ (Кондратьев, 2002: 374). We would add that the start of these new cycles implies not only the expansion of those ties, but also a change in their character (We will discuss this in more details below).
3. In general, World System processes are bound to influence economic processes (including medium period business cycles [e.g., Гринин и Коротаев, 2010]), hence, they are bound to influence K-wave dynamics. However, we also observe a reverse influence of those waves on World System development (which was actually noticed by Thompson). Kondratieff himself noticed the growth in the intensity of warfare and revolutionary activities during K-wave upswings (Кондратьев, 2002: 373–374). On the other hand, it is quite clear that those processes themselves influenced K-wave dynamics in a very significant way and world wars provide salient illustrations). It is quite clear that those K-wave students who pointed to an important role of military expenses (and inflation shocks produced by them) identified a significant (though in no way sole) cause of price growth (and decline) in the course of Kondratieff cycles.
4. As we have already mentioned above, breakthrough inventions (producing new technological systems) tend to be made during downswings, whereas their wide implementation is observed during subsequent upswings. The diffusion of those innovations throughout the World System is bound to affect significantly the course of K-waves, as the opening of new zones of economic development is capable of changing the world dynamics as a whole. Thus, in *Chap. 1* of our monograph on periodic economic crises (Гринин и Коротаев, 2010), we paid a considerable attention to the point that the vigorous railway construction of the last decades of the nineteenth century produced a major vector in world economic development (see, e.g., Лан, 1975; Мендельсон, 1959, vol. 2; Трахтенберг, 1963; Туган-Барановский, 2008 [1913]). Large-scale investments of British capital in the railway construction in the United States, Australia, India, etc. contributed to stagnation within the World System hegemon (and, finally, to the change of the center of this hegemony). Technological changes that start in one zone of the World System after their diffusion to other zones may produce such consequences that could hardly be forecasted. Thus, the development of oceanic and railway transportation led to vigorous exportation of cereal crops from the USA, Russia, and Canada that caused in the 1870s, 1880s, and 1890s the so-called world agrarian crisis (which affected significantly the second K-wave downswing but helped several countries to escape from the Malthusian trap [see, e.g., Grinin, Korotayev, & Malkov, 2010]).
5. Important events that take place within the World System may lead to an earlier (or later) switch from downswing to upswing (or, naturally, from upswing to downswing) within K-wave dynamics. As is well-known, the discovery of gold in California and Australia contributed in a rather significant way to the world economic (and price) growth during the second K-wave upswing, which was already noticed by Kondratieff (Кондратьев, 2002: 384–385).

Change of K-Wave Phases Against the Background of the World System Core–Periphery Interaction

Core and Periphery

We contend that the change of K-wave upswing and downswing phases correlates significantly with the phases of fluctuations in the relationships between the World System Core and Periphery, as well as with World System Core changes (the growth or decline of its strength, emergence of competing centers, their movements, and so on). Below we will describe our suppositions regarding possible causes of such a correlation. However, it turns out to be necessary to study the following questions: does this correlation emerge as a result of the casual link between the two processes? Is it caused by some other processes? Is not the causation pattern here even more complex? In any case this correlation appears especially important, as in the recent years one can observe a clear change in the interaction between the Core and Periphery of the World System. In particular, the World System Periphery (in contrast with what was observed not so long ago) tends to develop more rapidly than the core (see, e.g., Grinin & Korotayev, 2010b, 2015a; Korotayev, Zinkina et al., 2011a, 2011b, 2012; Коротаев и Халтурина, 2009; Коротаев, Халтурина, Малков et al., 2010; Малков, Божевольнов et al., 2010; Гринин, 2013б, 2013д; Гринин и Коротаев, 2010; Халтурина и Коротаев, 2010). This has become especially salient during the current global economic crisis.

Thus, what is the correlation between structural changes of the World System and periodic fluctuations within the K-wave dynamics?

We suggest that during the K-wave downswings the Core tended to subjugate, integrate, and pull up the Periphery to a greater extent than was observed during the K-wave upswings. It was during the K-wave downswings that the Core tended to expand vigorously (in various ways) into the Periphery by investing resources into it and by actively modernizing it. Those efforts and resource flows made a rather important contribution to the slow-down of the Core growth rates.

In contrast, during K-wave upswings the Core's activities were concentrated within the core part of the World System; in the meantime the balance of resource movement turned out to be in favor of the Core. Such a situation led to the acceleration of the growth rates of the Core countries (note, however, that this situation was not observed during the upswing of the most recent [fifth] K-wave).

The resource flow from the World System Core to the Semiperiphery and Periphery may proceed in various forms (military expenditures, FDI, aid, emigration, and so on). Of course, usually such actions are undertaken by the Core countries in order to obtain certain concrete gains: to get colonies, to obtain profits, to get influence in certain countries, to open markets, to get access to raw materials and so on (though the philanthropic component tended to become more and more pronounced with the passage of time). However, it takes any long-term investments a long time to pay for themselves (and sometimes these investments do not pay—

especially when they are made by politicians rather than businessmen). Often such a resource flow will proceed in the form of loans many of which are never paid back.

The resource flow to the Core could also be achieved in various forms—ranging from a direct plunder of colonies to importing very cheap commodities from them; it was also achieved through monopoly prices, unfair loans, and so on. The second K-wave upswing (the late 1840s to the 1870s) was supported to a very considerable extent by the flow of gold from such peripheral areas as California and Australia. In recent years one could observe certain exportation of capitals from the Periphery and Semiperiphery to the Core, as has been observed for China, Brazil, and Russia as regards the US securities; one may also note cheap Chinese exports, brain drain from India, etc.

Consider how this worked with respect to particular K-waves and their phases.

First Wave: The Late 1780s/Early 1790s–1844/1851

Phase A: The Late 1780s/Early 1790s–1810/1817

By this period the main colonial conquests of the pre-industrial epoch were already finished, the independence wars of the New World colonies had begun, and the main interests of the European powers were focused on internal affairs. In this period the resource flow from the Core to the Periphery was rather insignificant, whereas the one from the Periphery to the Core remained quite substantial. The Periphery and Semiperiphery (the USA, first of all) acted as suppliers of raw materials (cotton) for the development of the most advanced industrial sectors (Бурстин, 1993a, 1993b; Севостьянов, 1983; DiBacco, Mason, & Appy, 1992; Zinn, 1995).

Phase B (Downswing): 1810/1817–1844/1851

Europe (first of all, Britain and France) engaged in a rather active expansion in the Periphery—China, Algeria, Egypt, Turkey, and Latin America. British loans and investments went to Latin America and the USA (Мендельсон, 1959; Туган-Барановский, 2008 [1913]). There was a massive emigration from Europe (and especially Britain) to the West European offshoots; one could observe the active opening of Australia (e.g., Малаховский, 1971) as well as the South and the West of the USA. In this period, resources moved from Britain rather than to Britain. This partly accounts for the relatively bad conditions of the working class in Britain at this time (vividly described by Engels, 2009 [1845]).

Second Wave: 1844/1851–1890/1896

Phase A: 1844/1851–1870/1875

Europe again concentrated on its internal affairs (including the Crimean War, the unification of Germany and Italy and so on). Both the USA and Russia were also tied by internal struggles and reforms. A free trade system was established (e.g., Held, McGrew, Goldblatt, & Perraton, 1999). The flow of Australian and Californian gold reached Europe; one could observe a rather active catch-up of the European Semiperiphery (Гринин и Коротаев, 2010).

Phase B: 1870/1875–1890/1896

Europe actively expanded to the Periphery, actually the world was mostly divided between the Core powers through the final wave of colonial conquests (this involved some semiperipheral countries, first of all Russia conquered most of Central Asia). One could observe an active opening of agricultural lands in the American West (Бурстин, 1993а, 1993б; Севостьянов, 1983; DiBacco, Mason, & Appy, 1992; Zinn, 1995) and a very rapid development of Australia (e.g., Малаховский, 1971), as well as significant investments in the Periphery (especially in the railroad construction). Actually, during this period resources moved rather actively from Britain and some other European countries to the Periphery—for example, as loans for Latin America (e.g., Мендельсон, 1959; Tugan-Baranovsky, 1954; Туган-Барановский, 2008 [1913]).

Third Wave: 1890/1896–1945

Phase A: 1890/1896–1914/1928

During this phase Europe was concentrated on internal competition within itself (resulting finally in outright warfare), the USA was also concentrated on its own internal affairs (with the exception of a war with Spain); the preparations for the war and competition between Germany and Britain stimulated a technological race and economic growth (e.g., Grenville, 1999). One could observe a significant flow of resources from the Periphery, as well as the start of the transition of World System hegemony to the USA that, however, continued to be an importer of capital for a long time (e.g., Лан, 1975). Resources also flowed actively to Russia, Japan and some other semiperipheral countries where investors could find opportunities to introduce new technologies and receive high profits.

Phase B: 1914/1928–1939/1950

This phase saw activation of the Periphery and Semiperiphery, their struggle with the Core in various forms (India, China, Egypt, the USSR, Japan, etc.), the finalization of the transition of World System hegemony from Europe to the USA (see, e.g., Лан, 1976; Modelski & Thompson, 1996; Гринин и Коротаев, 2010). The continuation of the Core countries' control over their colonies required more and more effort and expense.

Fourth Wave: 1939/1950–1984/1991

Phase A: 1939/1950–1968/1974

The Core lost direct political control over the Periphery and was concentrated on its own internal affairs (including the West European integration); as a result of this concentration and the redistribution of capitals and technologies within the World System Core one could observe the Japanese, German, Italian, and Spanish economic miracles, as well as the consolidation of the Western world under US hegemony (e.g., Лан, 1978); one could also observe the emergence of new centers of development, including the Eastern Block and Japan (e.g., Попов, 1978).

Phase B: 1968/1974–1984/1991

The Core was 'attacked' by the Periphery economically—first of all through a radical increase in oil and some other raw material prices. In the meantime the West invested rather actively in the Periphery (especially, through loans to the developing countries).

Fifth Wave: 1984/1991–the 2020s(?)

Phase A: 1984/1991–2006/2008

This phase displays certain peculiarities in comparison with previous upswings, as during this period the main economic growth was generated not by the Core, but rather by the Periphery whose strongest countries moved to the Semiperiphery and even became new centers of growth.⁷ Many Core countries (especially in Europe) were concentrated

⁷This somehow resembles the situation during the third K-wave upswing, when the growth was generated in still semiperipheral Germany, the USA, and Russia, rather than in still hegemonic Britain.

on their internal affairs. In the meantime, one could observe a rather active exchange of resources between the Core and the Periphery. On the one hand, industrial production moved from the Core to the Periphery; on the other hand, one can observe a vigorous flow of cheap manufactured products from the Periphery to the Core, whereas the Western countries became financial net importers (especially, through the movement of petrodollars). The USA actively exchanged ‘paper’ dollars for manufactured goods from the periphery, which contributed to the explosive growth of the US public debt (see, e.g., Akaev, Korotayev, & Fomin, 2012). One may also take into account the Periphery—Core labor migration. Thus, at the first glance the balance of exchange looked as if being in favor of the Core. On the other hand, one should take into account the fact that those processes were accompanied by the acceleration of the economic growth in the Periphery and at the same time its slowdown in the Core—so, actually the Periphery was favored by those processes more than the Core. One may suppose that this was supported by a substantial transformation of national sovereignty that in turn opened borders for the flows of foreign capitals and technologies.⁸

Phase B: 2006/2008—the 2020s(?)

By the end of this phase we are likely to observe the weakening of the Core and the activation of new Core centers; one can expect a search for a new balance of power and new coalitions within the World System at this time (see Grinin, 2010, 2011; Grinin & Korotayev, 2010b; Grinin et al. 2016; Гринин, 2009a for more details).

Consider now some characteristics and causes of those processes.

Possible Causes of the Expansion

It is natural to suppose that particularly strong Juglar crises and depressions typical of K-wave downswings in the Core countries could stimulate the Core expansion into the Periphery.⁹ Such an expansion can be considered a result (and as a part) of counter-crisis measures undertaken by the Core countries. In addition, one may take into account the competition imitation effect—that the intensification of expansion efforts by one state would tend to provoke such an intensification on the part of competing states.

⁸ See Гринин, 2005, Grinin, 2008, 2009a, 2009b, 2010, 2012a, 2012b; Grinin & Korotayev, 2010b; Гринин, 2008a, 2008b, 2008r; Grinin et al. 2016; Гринин и Коротаев, 2009b, 2010 on the processes of decrease of sovereignty prerogatives.

⁹ On the other hand, the weakening of the Core makes it possible for the Periphery to undertake counter-expansion, as was observed in the 1970s and early 1980s as regards fuel prices. Their explosive growth led to the flow of resources from the Core to the Periphery.

In what way does the expansion contribute to the additional slow-down of economic development during the downswing?

1. In the course of such an expansion the energy of the Core will tend to become exhausted.
2. In addition, the Core powers could be exhausted by their struggles over their control over the World System Periphery. In any case the growth of this control involved substantial expenses (and sometimes serious destruction). In the previous periods this could have additionally weakened the Periphery. On the other hand, results of mutually beneficial expansion may be felt only with a substantial lag.
3. On the other hand, the rapid development was often hindered by the insufficient congruence of the economic structures of the Core and Periphery, a huge gap in the levels of economic development that was observed in many cases.
4. One cannot exclude that we are dealing here with a sort of positive feedback: the worsening of the economic situation in the Core stimulated its expansion to the Periphery, whereas the growing expenses to support this expansion may have worsened the situation in the Core.
5. As a result of the active integration of the Periphery into the World System, the transformation of the Hinterland into Periphery, a part of the Periphery into Semiperiphery, and the formation of new centers in the Semiperiphery, the World System expanded, the number of links and contact intensity within it increased explosively, etc.; this, however, led to a certain slowdown of World System economic growth.
6. Downswings are also connected with the weakening of the old Hegemon. This weakens the structural congruence of the World System and supports the trend toward the slowdown of economic growth rates. We are likely to observe such a pattern in the forthcoming years. On the other hand, it appears virtually impossible to replace the USA as the World System Hegemon, because the USA is a multifunctional Hegemon, whereas no other power will be able to play such a role in the forthcoming decades. That is why there are grounds to expect the reconfiguration of the World System as a whole (see Grinin, 2010; Grinin & Korotayev, 2010b; Grinin et al. 2016; Гринин, 2009a, 2012a for more details).

Slowdowns of the world economic growth are often connected with the slowdown of the economic growth of the Hegemon.

During Upswings the Resource Movement Balance Tended to be in Favor of the Core

1. During the upswing, the World System Core tended to concentrate on its internal affairs (including the struggles between the Core countries), and consequently it tended to move less resources to the Periphery.

2. Resource accumulation, restructuring of relationships within the core, as well as the emergence of new (and especially military) technologies stimulated the escalation of hegemonic struggles within the Core.
3. By themselves those struggles and wars contributed to the acceleration of both inflation and economic growth (thus we are dealing here with a certain positive feedback).
4. An important factor regarding the change of resource movement balance in favor of the Core was constituted by the fact that the previous investment started to produce returns; in particular, long-term investments in the infrastructure started to produce results; the trade-financial links started to work, scarcely populated territories were peopled (as was observed, e.g., in Australia in the first half of the nineteenth century), and so on.
5. On the other hand, new peripheral regions were involved in global trade. Those regions in order to maintain their participation in global trade had to export their commodities with reduced prices (which often implied unequal exchange—see Гринин и Коротаев, 2012 for more detail).¹⁰

It is also essential to take into consideration the fact that in the last two decades the balance of economic power in the world (between the Core and Periphery of the World System) changed dramatically under the influence of various factors, including the deindustrialization of the West (see Grinin & Korotayev, 2015a). So the mechanisms of these long cycles of interaction between the World System core and periphery (as well as those cycles closely associated with them, i.e. Akamatsu cycles, spelled out in *Chap. 4*) can change. As a result, the movement of capital and industries within the World System is described by such models less adequately now than before.

In any case it is worth mentioning that such core-periphery long cycles strongly influence processes of the Great Divergence and the Great Convergence (see Grinin & Korotayev, 2015a). In particular, these processes (together with the scientific and technological progress and changing technological modes) affect the transformation of technological paradigms and influence the diffusion of technologies from the Core of the World System to its Periphery and Semi-periphery. They can be considered as an important reason for the shift to convergence, especially starting from the 1980s when an active phase of the so-called deindustrialization of the West began. It appears appropriate to reproduce here the following passage from our earlier Springer monograph:

¹⁰ Note, however, that during the fourth K-wave downswing and the fifth K-wave upswing one could observe the change of the World System trend toward the growing divergence between the Core and Periphery to the trend toward convergence. Before this switch of the global trends the gap between the Core and the Periphery tended to increase; now it tends to decrease (Grinin & Korotayev, 2015a; Korotayev, Zinkina et al., 2011a; Коротаев и Халтурина, 2009; Малков, Божевольнов et al., 2010; Коротаев, Халтурина и Божевольнов, 2010; Гринин, 2013b; Халтурина и Коротаев, 2010). As a result, as has been mentioned above, we could observe the decrease of the gap between the Core and the Periphery already during the fifth K-wave upswing. Note, that if the hypothesis that we have spelled out above is true, then we should expect the acceleration of the Core–Periphery convergence during the current (fifth) K-wave.

“Deindustrialization can be defined as a decline in the share of industry in the GDP of the countries of the West, as well as in employment in manufacturing. The process of deindustrialization actually started in the mid-1960s, first in the USA; however, in Japan and Europe this process lagged behind. The share of manufacturing employment in the USA declined from 28 % in 1965 to 16 % in 1994. In general, in developed countries the share of manufacturing employment declined from 28 % in 1970 to 18 % in 1994 (Rowthorn & Ramaswamy, 1997). At the same time, the share of services employment rapidly grew. However, this phase of deindustrialization was mainly connected not only with a transfer of industrial technologies to developing countries or the preferential establishment of new factories there, even though the process was under way (see Amsden, 2004) but also with the rapid growth of other economic sectors including information production and services. For this reason, many economists mistakenly believed that North–South trade had very little to do with deindustrialization and with the growing share of low-skilled workers in the developing countries (Bhagwati, 1995; Krugman, 1996; Krugman & Lawrence, 1994; Lawrence & Slaughter, 1993). Later the researchers had to admit that in this respect the role of external trade with low-wage economies showed some signs of strengthening in the 1990s and early 2000s (Debande, 2006).¹¹ On the whole, the rapid growth of the service sector, including complex and qualified services (e.g. informational, medical, financial, etc.) together with the extension of free trade, free capital transfer (see below), strict environmental laws, demographic deterioration in the countries of the First World, and the growth of the human capital development level in the Third World made the transfer of production to peripheral countries more profitable. So, the initiation of the active phase of deindustrialization turned out to be an active phase of industrialization in many developing countries. Let us point out once again that TNCs played the most important, actually a defining, role in this process, as under free-trade conditions it was more profitable and even simply necessary for them (in order to produce competitive products) to substitute high-paid workers of their own countries with the low-paid workers from the developing countries. As a side note, this slowed down the development of robotics which was actively developed in the 1960s, 1970s, and 1980s. Since the productivity in services grew less rapidly than manufacturing productivity (Rowthorn & Ramaswamy, 1997); this process contributed greatly to Convergence. First, the industrial share in the developing countries' GDP grew very quickly; second, working efficiency grew faster than in developed countries. Thus, due to the shortage of demographic resources, scientific and technological progress supported the move of production from the First World countries to the Third World countries, at the same time making it profitable. The economy of every country is known to comprise different sectors, starting with agriculture. Yet, their hierarchy changes together with the development of innovative spheres within the economy. The less innovative sectors lose their share in economy, while the new ones expand. But within the global economy, due to the international division of labor, the situation is different, and the economic share of less innovative sectors might even increase. The reason is that the former technologically leading sectors, when leaving the World System Core, move to other parts of the World System, not as leaders with the prefix ‘ex-’ but as actual leaders there.¹² First, this occurs in underdeveloped countries via the development of their own production in the ex-leading sectors by means of adopted (imported) technologies. Second, this happens due to the actual transfer of old sectors to the less-developed countries (as has already been mentioned, this process has been going on during the last two or three decades within the process of the deindustrialization of the West). Thus, the structure of the international division

¹¹ For the analysis of the waves of scholarship in the studies in deindustrialization, change of vectors of researchers' interests and estimations during the last 40 years see High, 2013.

¹² The problem of the leading sector has been considered in different aspects in Kuznets, 1926, 1930; Modelski, 1987; Modelski & Thompson, 1996; Rostow, 1975; Rasler & Thompson, 1994; van Duijn, 1983; Thompson, 1990; Thompson, 2000, see also: Rennstich, 2002.

of labor, which is generally the World System's most important axis, to a certain extent reflects the historical succession of leading sectors and makes it possible for a new mode of production to emerge in the World System core. But the new wave of technologies requires not only the presence of an innovation cluster but also a 'free space' in the leading countries in order to re-orient the workforce. While capital and labor are being reoriented, the old basic commodities should be produced elsewhere in sufficient quantity so that the economy with an emerging new leading sector could have more opportunities. This means that it should get rid of the less-innovative commodities. Otherwise, in the situation of basic commodities shortage, it would be more difficult to concentrate on innovative ones which, despite their importance, becomes less connected with people's basic needs (compare food, clothes, and even metals, on the one hand, with Internet and specific services, on the other). Such a release becomes possible due to the import of goods whose production becomes unprofitable. Far from everything is logical here; the process of transformation proceeds with difficulty, but the logic of the process contributes to the World System's economic growth and provides opportunities for innovative breakthroughs in different regions of the World System. In fact, this is a way to introduce new economies into the operating arena of a new production principle. Even if a number of societies do not fit the principle yet (as at present many countries of the world do not really achieve the appropriate level for the scientific and information production principle), anyway to a certain extent they are getting involved in it (at least in large cities where there already exist some advanced technology centers). Moreover, they become a part of the international division of labor which is formed under the influence of a new principle of production. Therefore, the adaptation of new waves of innovations should be supported by technology and capital transfer to the less developed parts of the World System in order to compensate for the volume and range of commodities not produced anymore in the core" (Grinin & Korotayev, 2015a: 131–133).

One of the mechanisms of such shifts within technological modes can be interpreted within the flying geese paradigm which was developed in the late 1930s by the Japanese scientist Kaname Akamatsu (in the early 1960s his works appeared in English [Akamatsu, 1961, 1962]), for a detailed discussion of this theory see *Chap. 4* below.

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