Research Note

Kondratieff waves in global invention activity (1900–2008)

Andrey Korotayev *, Julia Zinkina, Justislav Bogevolnov

"System Analysis and Mathematical Modeling of the World Dynamics" Program, Russian Academy of Sciences, 30/1 Spiridonovka, Moscow 123001, Russia

ARTICLE INFO

ABSTRACT

Our study has revealed an unusually clear K-wave pattern in the dynamics of the number of patents granted annually in the world per 1 million of the world population. 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 decreases during K-wave B-phases ("downswings"). This pattern apparently goes counter to the logic suggested by Kondratieff, Schumpeter and their followers who expected the increases in the invention activities during B-phases and their decreases during A-phases. However, this contradiction is shown to be only apparent. We suggest an explanation that accounts for the detected pattern without contradicting the essence of Kondratieff–Schumpeter theory.

© 2011 Elsevier Inc. All rights reserved.

1. Introduction

A Russian economist writing 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 values of respective indicators followed by phases of decline [1–6]; the period of these apparent oscillations seemed to him to be around 50 years.

Kondratieff himself identified the following long waves and their phases (see Table 1).

The subsequent students of Kondratieff cycles identified additionally the following long waves in the post-World War I period (see Table 2).

2. Mechanisms of K-wave dynamics. "Cluster-of-innovation" hypothesis

A considerable number of explanations for the observed Kondratieff wave (or just K-wave [11,22]) patterns have been proposed. As at the initial stage of K-wave research the respective pattern was detected in the most secure way with respect to price indices, 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 [23–25]. Note that in recent decades such explanations went out of fashion, as the K-wave pattern stopped to be traced in the price indices after World War II [10,26].

Kondratieff himself accounted for the K-wave dynamics first of all on the basis of capital investment dynamics [5,6,27]. This line was further developed by Jay W. Forrester and his colleagues [28–31], as well as by A. van der Zwan [32], Hans Glisman, Horst Rodemer, and Frank Wolter [33] *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.

---

* Corresponding author.
 E-mail address: akorotayev@mail.ru (A. Korotayev).

Table 1
Long waves and their phases identified by Kondratieff.

Long wave number	Long wave phase	Dates of the beginning	Dates of the end
One	A: upswing	"The end of the 1780s or beginning of the 1790s"	1810–1817
	B: downswing	1810–1817	1844–1851
Two	A: upswing	1844–1851	1870–1875
	B: downswing	1870–1875	1890–1896
Three	A: upswing	1890–1896	1914–1920
	B: downswing	1914–1920	

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" [4,6].

This direction of reasoning was used by Schumpeter [34] 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.* [11,13,22,35–46]). Within this approach each Kondratieff wave is associated with a certain leading sector (or leading sectors), technological system or technological style. 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" [45,46]; whereas the forthcoming sixth wave is sometimes supposed to be connected first of all with nano- and biotechnologies [19,43].

3. Review of empirical evidence

After Kondratieff himself, the idea that breakthrough innovations' clustering should occur in line with the K-waves was first supported by Schumpeter [34], but was then subject to severe criticism by Simon Kuznets [46]. It was only in the 1980s that Mensch [35] provided substantial empirical evidence of an approximately 50-year rhythm in the introduction of major innovations into the market. Haustein and Neuwirth [47], Van Dujin [48], and Kleinknecht [49] added substantial amount of additional empirical evidence in support of the Kondratieff–Schumpeter hypothesis. Nevertheless, Silverberg and Verspagen [50], applying Poisson regression to their basic innovation series, stated that there was no innovation clustering, but only overdispersion, and the idea of a long wave in economic life being driven by clusters of basic innovations "has stretched the statistical evidence too far" [50].

On the other hand, Kleinknecht and van der Panne [51] have made an attempt to overcome the divergences of various basic innovation series compiled by different scholars (as these divergences could well have had a significant impact upon the conclusions made). They applied three variants of a weighting procedure to three basic innovation series independently compiled by van Dujin [48], Haustein and Neuwirth [47], and Mensch [35], coming to conclude that with each version of weighting, "the differences in mean numbers of innovations for pre-defined periods are highly significant", and "compared to the classical dating by Kondratieff, there is a 12 years lagged fluctuation in the innovation series" [51].

Thus, it is evident that there is still no unanimous agreement among the students of technological innovation dynamics with regard to the issue of long waves in technological innovation dynamics.

4. Test, discussion, and conclusion

In order to re-test the Kondratieff–Schumpeter hypothesis on the presence of the K-waves in 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 1 million of the world population in 1900–2008. For 1985–2008 WIPO publishes direct data on the total number of patent grants in the world per year [52]. For 1900–1985 we calculated this figure by summing up the data for all

Table 2
"Post-Kondratieff" long waves and their phases.

Long wave number	Long wave phase	Dates of the beginning	Dates of the end
Three	A: upswing	1890–1896	From 1914 to 1928/29
	B: downswing	From 1914 to 1928/29	1939–1950
Four	A: upswing	1939–1950	1968–1977
	B: downswing	1968–1974	1984–1991
Five	A: upswing	1984–1991	?
	B: downswing	?	?

Sources: [7–18]. For a discussion of the possible datings of the 5th K-wave see, *e.g.*, [12,19–21].