

2

Kondratieff (K-) Waves in the Modern World System

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Abstract

Contemporary Kondratieff wave studies show two tendencies: one, a macroeconomic analysis that maps long trends of prosperity and depression with GDP data, but second, a sectoral approach that traces the influence of K-waves of basic innovations, and the rise of a succession of leading industrial and/or commercial sectors on the emergence of a global economy. What is more, K-waves are a not stand-alone feature of the modern world system but one in a cascade of processes that have shaped its emergence. They stand in a close relationship with world politics, democratization, and globalization. An interesting question yet to be answered concerns the character of the next, K20, wave.

Keywords: *Kondratieff waves, K-waves, sectoral vs macroeconomic approaches, world politics, democratization, globalization, the next K-wave.*

Economic crises, and more generally, fluctuations in the output of the world economy, have drawn the attention of scholars and practitioners for the best part of the 20th century, and since. Some of them saw these movements as the product of internal changes and external shocks; others saw them as the harbingers of an imminent collapse of capitalism. Among the first to draw attention in a sustained manner to long-term regularities in the behavior of the leading capitalist economies was Nikolay Kondratieff (1984 [1925]), an economist writing in the 1920s. Statistical work on the behavior of prices and some output series for the United States, Britain and France since the 1790s led him to conclude that the existence of long waves as a regular feature of such economics was quite probable. He saw the capitalist world economy as evolving and self-correcting and, by implication, he denied the notion of an approaching collapse of capitalism then current among Marxist economists.

In the 1930s, Joseph Schumpeter endorsed this concept and named the pattern the Kondratieff wave, a name that has since been attached to this phenomenon, but that hardly settled the matter. Keynesianism explained much that needed to be known about economic depression, and in the years after 1945 the existence of the 'Kondratieffs' remained in contention, and to this day neo-classical economists remain wary of them. In fact, the 'Schumpeterians',

Kondratieff Waves: Dimensions and Prospects 2012 65–76

the 'Austrian School', hold a minority position among economists. But since the 1970s, as the post-World War II expansion slowed down attention was drawn to it once again, and new research especially on innovation, combined with a wealth of new statistical data, moved the subject forward in an important manner.

1. The Sectoral and the Macroeconomic Approaches

This is not the occasion to review a century's worth of writing on Kondratieffs. At this point, it might suffice to draw the distinction between two possible ways of looking at these processes. One of them relies for evidence on *macroeconomic* data, such as GNP, and also Gross World Product (GWP) fluctuations, and changes in the relative size of GDP as evidence of economic success or failure. This tendency, reinforced by the recent availability of such data, harks back to the earlier search for mapping the incidence of market crashes and other economic crises as evidence for the instability of the capitalist system. Its watchwords are prosperity and depression, and wealth creation. Long-term movements in such indices would then be seen as evidence for Kondratieff waves.

The contrast here is with a *sectoral* approach which concedes that the rise of new industrial and/or commercial sectors might indeed be a source of instability but which also argues that basic economic (and technological) innovation and structural and thus qualitative change in the world economy are the enduring sources of economic growth and adaptation to new conditions and therefore stabilizing over the longer run. Successive Kondratieff waves would then represent a narrative of global economic evolution, a key terms of which are innovation and its diffusion. Kondratieffs of the structural variety may simply be called K-waves.

Let us therefore define K-waves in particular as a pattern of regularity characteristic of structural change in the modern global economy. Some 50–60 years in length, it consists of an alternation of start-up periods of slow build-up of globally significant innovations, with others of high growth, chiefly in lead industries, but influencing the entire world system. The growth of the IT (information technology) computer-internet sector in the past several decades is an excellent example of a K-wave and the extensive influence of that process, reshaping the economy, and moreover, is beyond any doubt. The study of this pattern helps to trace the rise of the global economy and aids in long-range study of the modern world system.

2. Leading Sectors and Global Economic Innovation

The emerging view, now broadly characteristic of a significant body of scholarship, privileges globally-significant innovation, and leading sector expansion (see, *e.g.*, Rostow 1978; Van Duijn 1983; Freeman 1983 and the work of the Sussex Group; Berry 1991; Modelski and Thompson 1992, 1996; Modelski 2008b) and it might be summarized as follows.

K-waves have been so far processes characteristic first of all of a lead national economy (such as that of the United States in the 20th century, or Britain

in the 18–19th centuries) that are then diffused world-wide by such mechanisms as sheer emulation, and by world trade in products and services of leading sectors. In the high-growth period of new sectors they become characteristic of the global economy as a whole. Then they alter the attributes of the world economy, more visible in global data series than in those of national economies.

K-waves concern output, rather than prices, and sectoral output surges and targeted infrastructural investment in the world economy rather than the general macroeconomic performance (GNP growth) of national economies. They should not be sought for in the ups and downs of such indicators as gross domestic product and must be distinguished from shorter-term business cycles and financial crises. However, high-growth periods for leading sectors tend to translate into a good deal of economic expansion and prosperity; they also constitute a substantive basis for globalization.

K-waves unfold as phased processes that imply, for each particular sector, S-shaped growth (or learning) curves (as distinct from expecting sine curves when graphing world GNP data). Over a period of some 50–60 years, we observe a period of slow start-up, followed by fast growth rates, and ultimately, a leveling-off. Each wave is different in kind from the last one, in contrast with cycles, seen as mechanical fluctuations in attainment of some uniform quantity. The start-up period of the next leading sector is also the period of flattening growth rates, declining profits, and severe competition for the previous lead industry; this transition between two leading sectors peak may be known as downswing.

K-waves arise from the bunching of basic innovations that launch technological revolutions that in turn create leading industrial or commercial sectors. In Joseph Schumpeter's classic formulation, such innovations concern new products, services, and methods of production, the opening of new markets and sources of raw materials, and the pioneering of new forms of business organization. In that sense, K-waves are caused by the demand for solutions to new problems, and the supply of such solutions by innovative enterprises and entrepreneurs. Each such wave therefore has its own individual innovative character, and can be named accordingly, as in Table 1. Viewed over the modern world system, they constitute the story, an outline of a narrative, of the emergence of the global economy.

Each K-wave has its own characteristic location in space and time. Britain's cotton wave was centered on Manchester. The Information (IT) K-wave (K19) is preferentially seen as originating in the United States, in California's Silicon Valley, and in Orange County, and in Washington State's Seattle.

K-waves also have a clear location in time, and can be dated. There is no standard listing, but following Kondratieff's practice, there is some agreement on the four or five most recent ones. Albeit hesitantly, some historians and world system theorists now extend such dating further into the past.

Table 1 offers one recent scheme reaching all the way back to Song China, and grounded in the argument (advanced *inter alia* by William McNeill) that the beginnings of the contemporary market economy might be traced to that source one millennium ago. The dates shown next to each K-wave are for the start of hypothesized start-ups, and the transition period that follows, with the high growth peak reached only some decades later. All such dates must, of course, be regarded as approximate. Such specificity is lacking in world GNP analysis.

Table 1. Global economics and politics co-evolving in the modern world system

1. K-Waves	2. Global leading sectors	3. Date	4. Long Cycles	5. System-builders
Market economies	*	** Transitions		
K1	Printing and paper	930	LC1	Northern Song
K2	National market	990		
K3	Fiscal framework	1060	LC2	Southern Song
K4	Maritime trade	1120		
K5	Champagne Fairs	1190	LC3	Genoa
K6	Black Sea trade	1250		
K7	Galley fleets	1300	LC4	Venice
K8	Pepper	1350		
		** Global nucleus		
K9	Guinea gold	1420	LC5	Portugal
K10	Spices	1492		
K11	Baltic trade	1540	LC6	Dutch Republic
K12	Asian trade	1580		
K13	American plantations	1640	LC7	Britain I
K14	Amerasian trade	1680		
K15	Cotton, iron	1740	LC8	Britain II
K16	Railroads	1792		
	*World market		**Global organization	
K17	Electric power, steel	1850	LC9	USA
K18	Electronics, oil, autos	1914		
K19	Computers, internet (IT)	1973	LC10	
K20		2030		

Notes: Based on Modelski and Thompson 1996: 137, table 8.5.

* periods of the world economy process

** phases of global political evolution

Each K-wave has its own special character and specialization but each in its own way also changes the structure of the world economy. That is why a sequence of K-waves gives rise to structural transformations. Hall and Preston (1988) have shown that the three most recent K-waves (each based on electrical energy, those that launched *inter alia* the telegraph and electric power, radio and electronics, and computers and the information industries) might jointly be seen as the carriers of the information revolution that is still in progress. Our Table 1 also suggests that each cluster of four K-waves might have its own coloration, and the three most recent K-waves (K17–19) might be seen as constructing an ‘information age’ yet to be completed.

Only in such an extended time-frame can truly long-term processes such as globalization be properly observed. No such a long-term perspective can be expected from world GNP studies if only for lack of data but also because of difficulty of using such a concept in that early context.

In sum, the sectoral approach to Kondratieff appears well positioned to capture the global innovative focus of the forces that shape the world economy. As we about to show below, it is also better suited for clarifying the complex web of interactions among economic, political and other structural processes of the modern world system. That way, it makes possible a fully analytical approach to the study of globalization.

3. K-Waves and the Modern World System

This ‘sectoral’ analysis of K-waves has so far been one of a ‘stand-alone’ process, treating it as the sole object of observation, with ‘wars’, at best, as only sources of external ‘shock’. That has also been the tendency in much of the Kondratieff wave literature. An implicit ground for such treatment might have been the conviction that such grand movements of the world economy must be basic to the functioning of all of the world system, hence the ultimate determinants of the world's social trajectory.

That assumption might well be questioned. Economic processes are indeed foundational to the working of the world system, for they rank high as factors that condition growth, that are relatively high in energy and necessary for mobilizing resources, but they do not suffice to complete social organization. That is why they cannot be viewed in isolation from other, equally significant processes. Next in importance as conditioning factors (in a cybernetic hierarchy) are those agent-based processes that work to create and operate the world's political systems, long cycles of global politics, the drivers of global political evolution.

In contrast with conditioning factors there also are controlling factors, relatively high in information, that cannot be ignored, especially in the longer run, and also at the global level: they are both the forces of community formation rife with symbolic communication, the solidarity-builders that make increasingly extensive, long-term cooperation possible. There are also those that are opinion-shaping, higher in information and reliant on learning, science and the media, for

helping to spot global problems, and aiding in coping with them, by controlling the necessary plans or programs.

3.1. Power Law

Overlaying all this is the finding that the relationship between these four basic, agent-level processes: the K-waves, and the political, social, and cultural ones, are governed by a power law that maintains that the periods of these movements of the global system are multiples of the period of the K-wave: and in particular that the two K-waves equal the length of one period of the global politics' long cycle, and are also synchronized with it, as in Table 1 (Devezas and Modelski 2011).

These are the considerations that lead students of K-waves to study the interdependence of K-waves and the other global processes. At one level, K-waves are seen as an endogenously generated response to problems facing the world economy: basic innovations as responses to system problems, such as railroads meeting the demands of a rising industrial economy, or data-processing as responsive to the needs of the military forces or the space program. In that sense, K-waves are not the response to random shocks, as some economists have called for instance wars, but to predictable influences that make them coordinate with global political change; they may be seen as supplying the resources, hence the necessary conditions, for financing enterprises of system-building and global leadership. While it is clear that major warfare has so far marked the path of system-building it is also obvious that the evolutionary character of the enterprise means that major warfare is not an inherent feature of the emerging world system.

3.2. K-Waves and World Politics

Some students of International Political Economy (such as Joshua Goldstein 1988) have recognized but a loose connection between long economic waves and the fortunes of major powers in the modern world. A much stronger tie has been urged by Modelski and Thompson (1996) who have argued for an essential structural relationship between K-waves and global political leadership in system-building. A survey of economic history shows, as in Table 1, columns 1–3, a series of K-waves as the rise of successive globally significant lead industries; columns 4 and 5 of the same table also displays tightly linked to a parallel (and structurally similar) process, the rise of system-building world powers, hence significant change in world political arrangements. That latter process is sometimes referred to as the hegemonic or leadership cycle, or more precisely in this context, as the long cycle of global politics (without implying that the process animates an unchanging system). Notice that this is a 'rise' (via S-type learning), but not 'rise and decline' of lead industries, and lead powers; those who have participated in this process endure and largely continue to play key roles.

While the exact conditions of that process remain a matter of some debate, the existence of a succession of world powers in modern world politics is now taken for granted, and the similarities in the several approaches are now greater than the differences. Participants in that debate, including Robert Gilpin, Immanuel Wallerstein, and Paul Kennedy have all recognized the role of economic growth in that process. It can further be shown that system-building world powers that served as foci of modern world politics, also accounted for the major proportion of economic innovations.

The right-hand columns 3–5 in Table 1 list the powers that in the past five hundred years, since about 1500, animated the global system via great enterprises of system-building (and contended with successive challenges from *inter alia* Spain, France, and Germany). It also shows, for the early modern era, that starts with Song China, two Italian republics, Genoa and Venice, that might be regarded as prototypical of later oceanic powers, whose trading networks organized a good part of the maritime routes while the Mongols, and then Timur, held sway over continental Eurasia.

The rise of each such power is seen to be coordinate with K-waves in two ways: in space, in as much as each K-wave is initially largely located in the world power of that period, and also in time, in as much as the timing of these two processes of change is synchronized. What is more, an economy that launches lead industrial sectors (but not necessarily with the biggest GWP) builds the foundation for a claim to leadership in global system-building. In turn, attainment of leadership position in the global system establishes the political framework for a global economic order.

In that way, illustrating the working of the power law discussed in the previous section, each long cycle of global politics (numbered in Table 1 as LC1–LC10) has been matched, in the experience of the modern world, by two K-waves (numbered as K1–K20). A rigorous, data-based test of that hypothesis of synchronization is a study of early globalization in the case of Portugal (Devezas and Modelski 2008, amplifying Modelski and Thompson 1996). The first of the K-waves that were analysed in those studies, and labeled K9, Guinea gold, created a new system of trade along Africa's west coast, based principally on the demand for gold; the experience and the resources thus gained helped to create the necessary conditions for the second K-wave, K10 Spices, that went out to capture the pepper trade (a commodity profitably handled by Venice in the West, but also traded to the Far East) by extending the reach of Portuguese sea power into the Indian Ocean, and even to the South China Sea. The political aspect of system-building is marked by a complex of generation-long hostilities spreading from the Mediterranean via the Atlantic, to the eastern oceans, and illustrated by the record of building of Portuguese bases/fortresses serving as nodal points of a global political network. That record maps as a century long learning curve (Devezas and Modelski 2008: 44).

The same process might be observed three centuries later, albeit on a larger scale, as when the later 19th century industrial expansion in electric power, steel, and chemistry (K17), laid the foundation for the United States' role in the 20th century, in its world wars in particular, to be followed by K18, as when the peace settlements of 1945 laid the groundwork for the economic expansion of the post-war years, led by autos, oil, and electronics, complementing the parallel formation the groundwork of an inter-governmental 'international community'. The location of the (odd-numbered) K-wave has served as a leading indicator of the identity of the next system-building global leadership.

The relationship between the Kondratieff processes and war has long been of interest to students of these matters. Indeed, Kondratieff himself strongly hinted at the hypothesized link between these two phenomena. In particular he observed that wars and revolutions were more likely to occur during what might be called the long start-up, or the transition period. A striking reminder of that relationship was the Great Depression of the 1930s, sandwiched between the two World Wars, in the start-up phases of K18.

In an empirical study of that relationship in a long time frame Joshua Goldstein (1988) saw economic upswings associated with K-waves as increasing the probability of severe war. Brian Berry (1991) doubts such a connection and is troubled by the notion of an inherent tendency to war in the global political system. The record of modern K-waves so far has shown a close connection between the long cycle and the incidence of global wars, but that is not a sound prescription for the future (see discussion in Modelski and Thompson 1996: 56–62; Modelski 2006).

3.3. K-Waves and Democratization

The relationship between K-waves and democratization may be less obvious but is also noteworthy, and has been reciprocal, in that democratic practices have been innovation-friendly and favorable to entrepreneurship, and the rise of new industries; while K-waves have been central to rising global connectivity and the creation of the elements not just of a world market but also of a global community. Most generally, the significant lowering of the cost of information that has been the most recent result of this trend has had a positive impact on the world-wide spread of democracy.

As another glance at Table 1 will confirm, the home bases of K-waves have been societies that can be classified as freer and more open, relatively to their competitors and their environment – in fact, a democratic lineage. An early case was Song China, that clearly cannot be called democratic, but was for its time notably open, educated 'learning society', under 'civilian control'. Forms of representative government were prominent in the Italian and Dutch Republics, as well as in Portugal and Britain. It is since the mid-19th century that the K-wave-democracy connection has been demonstrably clear in par-

ticular relation to the United States. Innovation-engendering leading industrial sectors flourished first in environments favoring free flow of information, competitive markets, the rule of law, and openness to global problems, for innovation alone is not enough, it needs institutional support to create leading sectors.

The other strand of influences can be traced from K-wave system-building to an increasingly tightly connected world. As is also apparent from Table 1, in several instances, as, for example, in the Portuguese cases, the results of the K-wave process have been enhancements of the instruments and expansion of the products that animate world trade. The internet of the early 21st century is only the latest instance of higher connectivity, and it is that higher connectivity that has in turn favored the spread of democratic practices, often using U.S. or European examples as models to follow but retaining options of other ways too. In building a world market K-waves have put in place elements of a global community. But it is also clear that an increasingly interconnected world is also subject to new forms of instability.

4. K-Waves and Globalization: In a Cascade of Evolutionary Processes

For Nikolay Kondratieff (1984: 25–6, 35, 90) the long movements described by him were features of the capitalist world economy that was evidently evolving meaning that the processes he observed were evolutionary. Even his critics admitted that his concept of ‘phases of capitalist evolution’ deserved attention. But he was also acutely aware that the investigation of these processes was difficult because it called for a long period of observation for which lack of data was a severe problem, not forgetting the question of homogeneity. That is why his inquiries did not reach much further back than the nineteenth century. It is unfortunate that some students of this subject still regard long economic waves only as phenomena of the last century or two.

That makes Table 1 a foray into the past in the spirit of Kondratieff. It covers the modern era in its entirety (the ancient and classical worlds lacked global processes), and it makes it possible to explore, on its basis, the value of an evolutionary explanation. The weakness of such an explanation was one of the serious criticisms of Kondratieff’s original thesis (Garvy 1943).

An evolutionary explanation of K-waves is one that gives a reasoned account of the emergence of the modern global economy over the past millennium, and one that may project equally far into the future. That is the essence of the ‘mechanism-and-process’ approach applied in a world system setting (Devezas and Modelski 2011). Its first requirement is a set of initial conditions favorable to innovation: competitive markets, rule of law, open society, and responsiveness to global problems. Maritime access, possibly with an insular position, also helps. In such propitious circumstances, an evolutionary mechanism of learning sets in motion a phased process that generates variety, mobilizes resources, selects, and then consolidates innovations bearing on global problems,

translates them into fast-growing industrial or commercial sectors, and gradually diffuses them to other parts of the global economy.

Over a span of two generations (a generation being a basic unit of evolutionary time), the process reaches a peak, and its growth rate gradually flattens out, and tends to overlap with its successor, producing a succession of overlapping sociotechnical paradigms depicted in Table 1. The drivers of that evolution are large and small firms, often fresh start-ups launching innovative products that are, or are not, selected by consumers/buyers in the marketplace, and when selected, are diffused until they reach saturation in their global market place. The selective pressure is that of markets, but these markets might include large buyers, such as governments whose demands, and research, may stimulate innovation.

In a cascade of evolutionary processes, the K-(economic) wave coevolves not only with the political process of system leaders' rise that powers global political evolution, but also with that of global community-building, and also that of global opinion formation (via the rise of media, learning, and science) that shapes and legitimizes globalization. As noted earlier, much empirical evidence supports the conjecture that a power law is operating here: two K-waves synchronize with one long cycle of global politics (as in Table 1); four K-waves seem to be producing the current phase of democratization, and eight K-waves correspond to long swings of (emergent) world-wide consensus enabling globalization. That suggests systematic interaction and substantial interdependence, and makes K-waves a necessary ingredient of globalization (Modelski 2008a).

5. Questions

The two major propositions defended on this occasion are the following:

1. A K-wave, sectoral approach to the study of the global economy's long movements fuelled by innovation and system-building needs to be distinguished from a macroeconomic approach that maps the long-term trends of prosperity and depression of that economy. Both approaches have their own data bases, their preferred models, and their own merits.

2. K-waves are not a stand-alone feature of the modern world system but one in the cascade of processes that have shaped the emergence of that system. They stand in a close, co-evolutionary relationship with global politics, democratization, and globalization.

Important questions remain. At this time, consider just one set of these that concerns the timing, nature and future location of the next K-wave, the K20.

What is the likely timing of K20? When might its start-up be expected? Table 1 suggests 2030, and while that is obviously arbitrary, the onset of a new wave seems to be approaching later in the next decade, of the 2020s, some five decades since the dawn of the computer age, and to continue well past the mid-21st century.

What might we anticipate will be the nature of the next K-wave and what lead industries might it generate? Analysis presented here suggests that K20 will consolidate the achievements of the current four-K-waves (K17–20) period by producing a ‘wired world’. Such a world will need to select a new authority structure, more specifically, considering that this Information Age began with the industrialization of electric power, and led the world towards a vast increase in energy use, that in turn created problems that are changing the world's climate, it would be only fitting if the next step in shaping of a viable economy were to be a recasting of the world's energy industries into a clean mode that minimizes the consumption of fossil fuels.

What is likely to be the location of K20? The United States seems the favored entrant in this race, *inter alia* on account of its contribution so far to the Information Age. But China that recently became the world's greatest emitter of greenhouse gases is also the biggest participant in the internet, and is staking out an important lead in the search for clean energy sources. The race will be played out in the face of rising competition for global leadership in the face of urgent global problems, the pace of democratization, and continued pressures of globalization.

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