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A hard-science approach to Kondratieff's economic cycle

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ABSTRACT

In an effort to evidence the Kondratieff cycle more scientifically than the way economists do, physical variables are studied rather than monetary indicators. Previously published graphs are reproduced and updated here with recent data. A cyclical rather regular variation of energy consumption reveals a 56-year cycle. A dozen human endeavors/phenomena, such as bank failures, homicides, hurricanes, feminism, and sunspot activity are shown to resonate with this cycle. Possible explanations for this phenomenon may have to do with a climatic variation or with the length of time any individual actively influences the environment. There is some evidence that the cycle may be getting shorter in amplitude and duration in recent years. All quantitative confidence levels involved in these observations are poor by scientific standards and permit critics to question the very existence of this phenomenon.

1. Introduction

Claims for long waves in economic activity have existed since the beginning of the Industrial Revolution. Among the early proponents of economic cycles was William S. Jevons (1835–1882) who linked business cycles to sunspot activity (Jevons, 1878). Later Henry Ludwell Moore (1869–1958) linked business cycles to climate variations arguing that a rainfall cycle affects agricultural markets, which affect industrial markets (Moore, 1914). The Russian economist Nikolai D. Kondratieff (1892–1938) deduced an economic cycle with a period of about fifty years from economic indicators alone. His classic work in 1926 resulted in his name being associated with this phenomenon (Kondratieff, 1935). Joseph A. Schumpeter (1883–1950) tried to explain the existence of economic cycles and in particular Kondratieff's cycle by attributing growth to the fact that major technological innovations come in clusters (Schumpeter, 1939). More recently, Bert de Groot and Philip Hans Franses have found a multiplicity of cycles in innovations (de Groot and Franses, 2008). And Andrey V. Korotayev, Julia Zinkina, and Justislav Bogevolnov have evidenced Kondratieff waves in global invention activity (Andrey, 2011).

One could argue that Kondratieff's cycle is the most successful among long-wave postulations. His name yields a quarter of a million hits in a Google search, and an economic research organization called International N. D. Kondratieff Foundation has been established in 1992 accredited by the Russian Academy of Sciences. Its charter is to coordinate interdisciplinary research, organize conferences and competitions, and award medals to Kondratieff-related contributors. In Russian economic circles the whole thing takes on the airs of a cult with an inexhaustible list of publications, see for example issues of the *Kondratieff Waves* yearbook (Anon, n.d.-a).

And yet, Kondratieff's work has been challenged by many respected economists from the very beginning. Critics doubted both the existence of Kondratieff's cycle and the causal explanation suggested by Schumpeter. Among vocal critics has been American economist Murray Rothbard (Rothbard, 1978). He argued that business cycles are "emphatically not periodic." He called the Kondratieff cycle "mystical" and "the flimsiest 'cycle' of them all." He questioned and discounted Kondratieff booms/depressions, and presented arguments showing that the Kondratieff cycle may seem regular at the very most for only three-and-a-half periods. He also criticized the fact that it is evidenced by studying prices, which do not accurately reflect the state of the economy.

Kondratieff's postulation ended up being largely ignored by contemporary economists for a variety of reasons. Since then it came in and out of vogue with changes in the economic climate. In the final analysis, however, the postulation's greatest weakness may have been the boldness of the conclusions drawn from such ambiguous and imprecise data as monetary and financial indicators. These indicators—just like price tags—are a rather frivolous means of assigning lasting value. Inflation and currency fluctuations due to speculation or politico-economic circumstances can have a large unpredictable effect on monetary indicators. Extreme swings have been observed. For example, Van Gogh died poor, although each of his paintings is worth a fortune today. The amount of work or beauty in his paintings has not changed

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since his death; counted in dollars, however, it has increased tremendously. Even the monitoring of innovations and invention activity is subject to human bias and uncertainty that stem from the ambiguity involved in defining them and quantifying them.

A number of "hard" scientists have attempted to evidence Kondratieff's cycle by studying "physical" variables such as homicides and energy consumption. Deaths and watts consumed are not subject to speculation; they are unambiguously defined, and precisely measured. It was Hugh B. Stewart, a physicist, who first studied cyclical variations in energy consumption in America. He extracted a rather regular cyclical variation above and below the long-term trend of energy consumption in the U.S. (Stewart, 1989a). Cesare Marchetti, another physicist, replicated that cyclical variation, including more recent data, and demonstrated with a fair amount of success that many other social endeavors are synchronized with it (Marchetti, 1986). I replicated and augmented Marchetti's work in my book *Predictions: Society's Telltale Signature Reveals the Past and Forecasts the Future* ().

In the following sections I will reproduce some of the most convincing evidence for the existence of Kondratieff's cycle using physical variables and three more decades of data.

2. Energy consumption

There are historical data on energy consumption in the U.S. going back to 1850 (Anon, n.d.-b). In Fig. 1 we see the evolution of this variable up to the end of 2015 plotted versus time with 5-year sampling. The growth seems to be stepwise with two long steps and a shorter recent one. A logistic S-curve fitted to the entire range via a Chi-square minimization does a mediocre job describing the overall growth pattern. Smaller S-curves describe better the three growth steps. Similar graphs with only the first two steps have been previously published (Stewart, 1989b). At that time the third step had been sketched in—with an S-curve similar to the previous two—as a probable scenario for the future.

In Fig. 2 the deviations of the data from the overall S-curve trend have been isolated by taking the ratio of data to trend in Fig. 1. The consumption of electrical energy in the U.S. treated in the same fashion has been superimposed on the same graph. A sinusoidal wave with period 56 years—thick gray band—is there to guide the eye through a regular oscillation.

A similar approach can be applied to data concerning worldwide energy consumption per capita. Ausubel et al. have published a graph

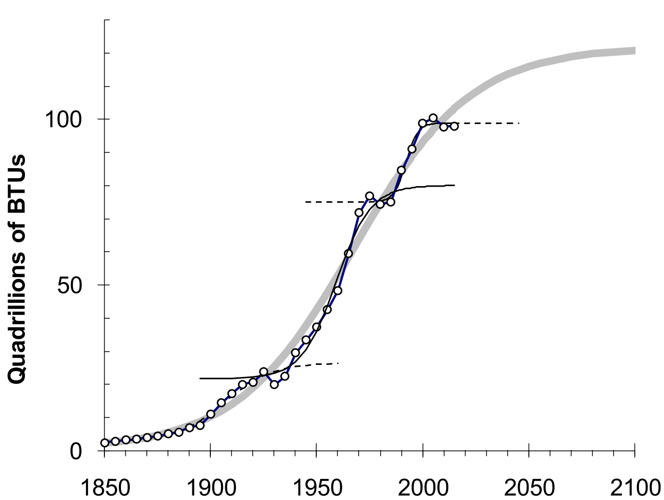

Fig. 1. Annual energy consumed in the U.S. sampled every five years. An overall logistic curve (thick gray line) fitted on the data helps identify three smaller sub-processes more amenable to logistic fits (thin and intermittent lines.)Data sources: *Historical Statistics of the United States, Colonial Times to 1970*, vol. 2, Bureau of the Census, Washington, DC. Recent data from the BP *Statistical Review of World Energy 2016*.

similar to that of Fig. 1 with data up to 1985 (Ausubel et al., 1988). I have updated that graph to the end of 2015 with data from the BP *Statistical Review of World Energy 2016*, and the Bureau of the Census, Washington, DC. Isolating deviations of the data from an overall S-curve trend, as was done earlier, I obtained the graph in Fig. 3.

There is an evident rather regular oscillation of the data with period of 56 years in both Figs. 2 and 3. It seems that energy is consumed more ravenously at some times than at others. Whether we look at the U.S. or at the entire world, energy consumption has been as much as 20% higher than we would have expected during some periods, and as much as 20% lower than we would have expected in other periods. Enhanced energy consumption translates to enhanced economic growth and prosperity whereas diminished energy consumption reflects economic recession, stagnation or depression. In other words, Figs. 2 and 3 produce independent evidence for an economic cycle with a period of 56 years otherwise known as Kondratieff's economic cycle.

It is noteworthy that there is a phase difference between the regular waves of Figs. 2 and 3, namely booms and busts come seven years earlier in the U.S. than worldwide. Another observation is that the U.S. data deviate significantly—both in timing and in amplitude—from the regular cyclical pattern beginning in 1990.

The correlation coefficient **r** between the time-series data and the idealized sine wave is perhaps more useful when expressed as $\mathbf{r}^2$ because it then represents the amount of structure in the data pattern that can be explained in terms of the regular sine-wave pattern. For the three variables plotted in Figs. 2 and 3, namely total U.S. energy, electrical U.S. energy, and worldwide energy per capita we have respectively 39%, 62%, and 51% of their pattern explained by the regular sine wave shown.

3. Other phenomena resonating with Kondratieff's cycle

In this section I will reproduce and update some other physical variables that have been seen to resonate with Kondratieff's cycle. In each figure a wide gray band representing a regular sine wave is sketched in to guide the eye.

3.1. Bank failures

Fig. 4 shows bank failures in the U.S., bank suspensions before 1933, and banks closed due to financial difficulties between 1933 and 2013. It is not surprising that bank failures peak close to the troughs of the energy-consumption cycle.

Data sources: *Statistical Abstract of the United States*, U.S. Department of Commerce, Bureau of the Census. After 1933, Federal Deposit Insurance Corporation.

3.2. Innovations and discoveries

At the top of Fig. 5 we see the appearance of basic innovation in 10-year time bins as they are defined by Gerhard Mensch (Mensch, 1979). The exact number of innovations may be subject to debate and personal bias cannot be excluded in their definition. The graph has been updated after 1960 with data on the number of patents for inventions worldwide, which has been taken as a proxy for the appearance of innovations for that period. On the right-hand vertical axis we see the percent deviation from a logistic-growth trend fitted on the total number of patents.

The variation over time for both the number of innovations and the deviations from the patent trend seem well synchronized with a cycle of 56 years (gray band). The peaks line up with the troughs of the energy cycle of Fig. 1 (the Kondratieff cycle). One could understand why innovations increase during economic hardship. It follows from the natural reaction of people to become more entrepreneurial when economically squeezed. But this reasoning conflicts with Schumpeter's explanation for the existence of Kondratieff' cycle namely that it is