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FIFTY-YEAR PULSATION IN HUMAN AFFAIRS

Analysis of some physical indicators

Cesare Marchetti

Long business cycles have been a subject of controversy between economists for the past hundred years. In this article a fresh approach is taken, forgetting money indicators, and looking instead at physicals and patterns of social behaviour. This new perspective very clearly reveals cyclic or pulsed behaviour in many areas with a period of about 55 years for at least two centuries. The patterns can be expressed in close mathematical form permitting quantitative forecastings to be made.

Keywords: social behaviour; cycles; forecasting

THAT HUMAN AFFAIRS run a cyclical course is an ancient observation. This is not unexpected where nature is so cyclical—the day, the moon, the seasons, the planets, all move about in never ending repetition.

The facts are so dominating that the idea of 'cyclicity' has entered the philosophy and the general conception of the world. All cycles have a hierarchical order terminating in a universal cycle of great length—just a billion years for the Hindus controlling the eternal repetition of the beautiful play.

Christian theologians of the third century, for reasons of internal consistency, declared time open, with a beginning and, presumably an end, an objective and a programme. That idea has been immensely stimulating for Western activism. But theologians were not interested in shooting at lower levels. So we remain entangled in the concept, with astronomers, geologists, geophysicists, climatologists, ecologists, sociologists, and economists all chasing around in search of cycles. Open-ended processes are fearful, and the cycle is protective. This is true even in Vico's spiral form: a little new, a lot of *déjà vu*.

I think the cycles we are dealing with are, in fact, pulsations, as there is a lot of new and only a little *déjà vu*. They are called economic cycles because they were originally discussed by economists. But they extend beyond economics, so that a more precise definition would be *long-term pulsations in social behaviour*.

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To be on the safe side, I measured all sorts of physical indicators, excluding money indicators. So my work could be considered complementary to that of economists. The results are fascinating. The signals that are so fumbled in economy as to have kept discussion alive for more than a century become crystal clear when 'physicals' are analysed. It is also fascinating in the philosophical implication that human society behaves like a homeostatic body, a concept perceived since antiquity but never proved quantitatively.

A time for infrastructure

Infrastructures are usually created through the superior decisions of decision makers who unfailingly are there to cut the ribbon and deliver the speech. Decision makers, however, seem to be only one step in the hierarchical system, with many other steps going elsewhere. If we analyse a type of infrastructure, eg, underground metros, we find an extraordinary regularity—I would even describe it as a 'coordination' in the way they are implemented. Figure 1 shows the 'starts' for the first line of each of all the world's metros.

These starts coalesce into three groups. Each group can be organized logistically by measuring the cumulative number of starts *v* time. The centre-points of the logistics are about 54 years apart. Since the first group has only two elements, I took the middle date. The third group of starters appears to be halfway on the logistic curve. While it is a tricky job to fit three parameter logistics when they are only halfway, it can be most instructive when one checks

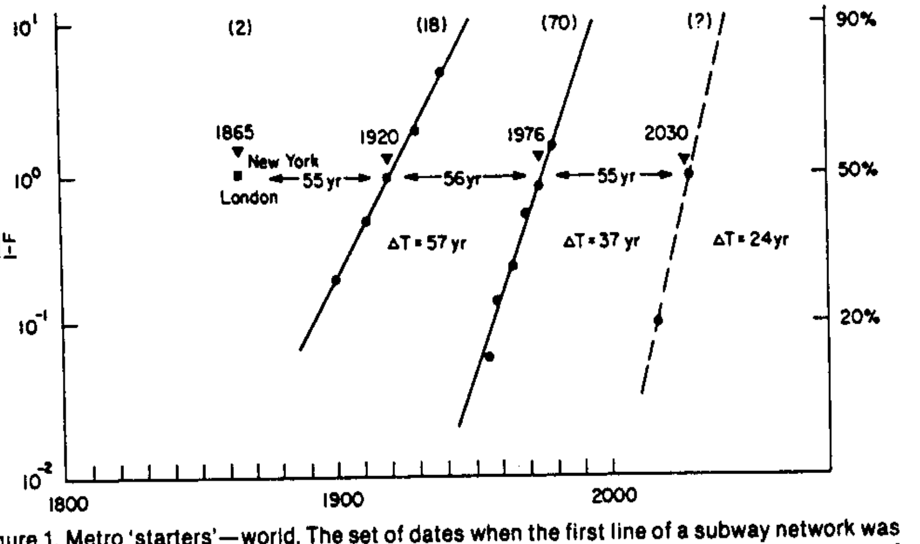

Figure 1. Metro 'starters'—world. The set of dates when the first line of a subway network was inaugurated are elaborated here. It appears that these dates, taken as a physical indicator of the beginning of the construction, cluster in three groups. Each group is analysed using the logistic fitting described in the appendix. The first group contains the starts for only two cities and cannot be fitted. The mean date is, however, taken for reference of the group. The second group contains 18 cities, was halfway in 1920 and has been fitted with a two parameter logistic, *N* being known *a posteriori*. The third group is a little more than halfway and has been fitted with a three parameter logistic as described in the appendix. *N* is calculated to be 70, the number of cities having their first metro line in this wave. The fourth group has been calculated from the regularities of the previous groups. We will have to wait until about 2030 to be able to check, it experimentally. ΔT is the time constant, ie, the period to go from 10% to 90% of the inaugurations.

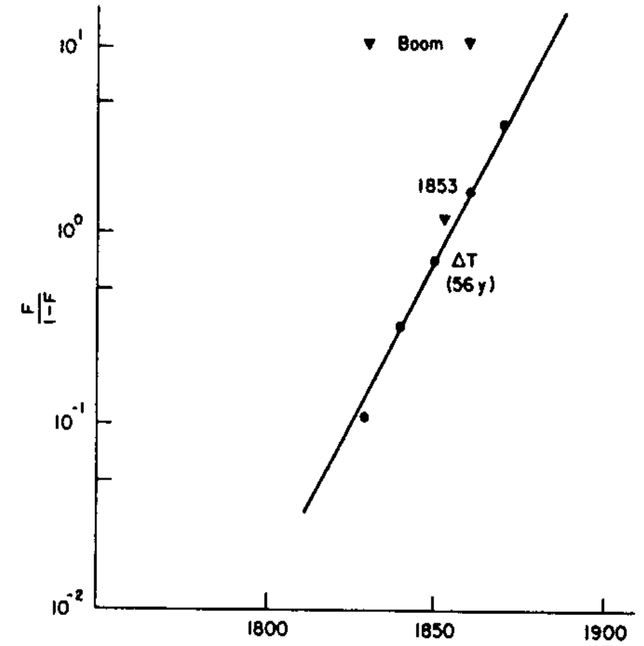

Figure 2. Railways saga starter dates (40 states over the world). This analysis of the inauguration dates of the first line of railway networks during the last century follows the same procedure as described in Figure 1. There were 40, and no new network has been started during this century. The fact that the set fits so well a logistic equation is a strong indicator that the world did operate as a single unit. This is characteristic of culturally connected systems. Also the starter dates for Gothic cathedrals follow the same equation, with a time constant of 200 years. The period of economic boom is indicated to show most of the *starts* were during expanding economies.

over the next few years how well the facts follow the implications. If the logistics fit, this would represent a great victory for the constraints and a suggestion for modesty on the part of the decision makers who then become only the active tendrils of 'Big Brother'—the system. Although the 54 years are an obvious reminder of the Kondratieff cycle, there is no real cycle involved. It is pulsation in activity.

Metros are a type of infrastructural innovation that keeps flourishing again and again. Other innovations are one season only, at least as starters. Canals were the craze from around 1750–1800, but people no longer appear to be interested in building canal *grids*. Railways were the next wave, dominating the nineteenth century beginning around 1825. The starter dates for about 40 grids worldwide are shown in Figure 2. Again, the organizing function is a logistic. Curiously enough, practically all of the world's railway grids are represented here, with no starts occurring in this century. These dates cover a period of about 50 years. If se examine the grids individually, we find that development involvedone or two pulsations, with about 50 years required to grow from 10% to 90% of the final length. Thereafter, each grid slowly contracted in a well-documented dimensional and functional decay. Despite all their intrusion and confusion, Italian railways now account for 10% of the national total of ton-kilometre traffic in goods and 5% of the passenger kilometres.

Figures 3a–3c show the development for Italian railways. The two main

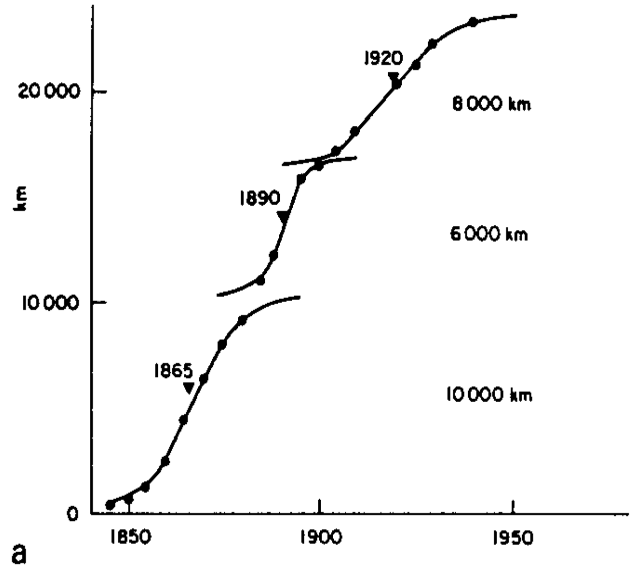

Figure 3a. Italian railways development. A condensed history of the development of railways in Italy, measured by the length of lines, is reported in these figures. In Figure 3a, the growth of the network is reported in linear form, with fitted logistics. It can be decomposed basically in two waves, one centered in 1865 and one in 1920, with a very short burst of activity around 1890.

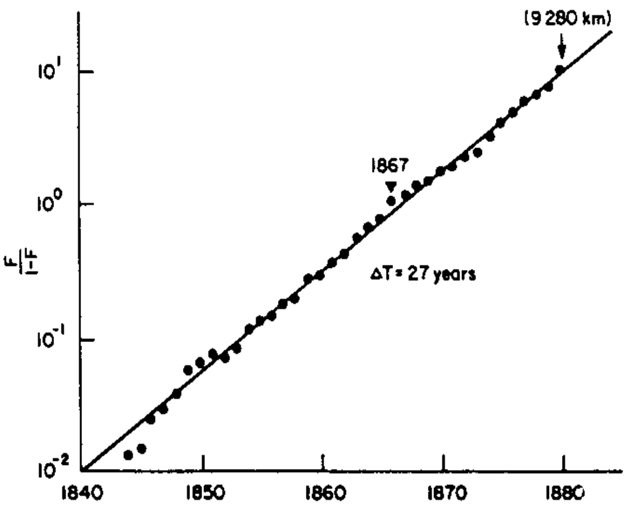

Figure 3b. Italian railways—first spurt (10000 km).

thrusts are separated by 55 years and, as we will see later, are anticyclical. Figure 4 describes the development of paved roads in the USA; Figure 5 illustrates the dynamic for telegraph lines in the USA. All of these developments have a time constant of about 50 years. What I find most intriguing is that the saturation parameter—or the size of the niche, using biological terminology—appears to remain constant throughout the growth period, implying an implicit knowledge from the beginning. Exactly how the signals operate is a challenging mystery.

If we take the series canals–railways–paved roads, then the natural next in

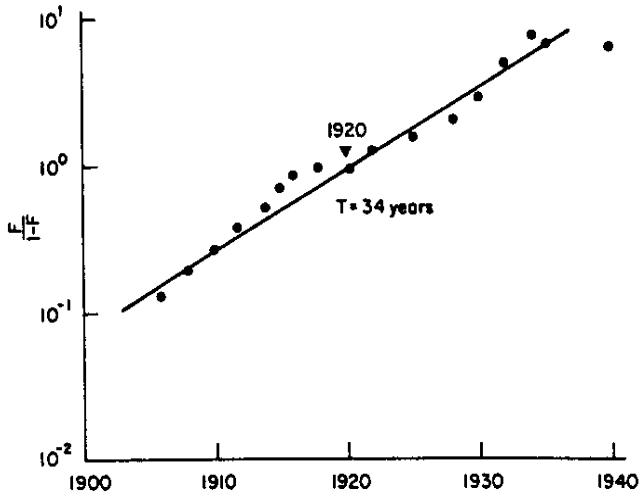

Figure 3c. Italian railways—second spurts (8000 km). The analysis is reported in detail (year by year) in Figures 3b and 3c, and presented in the usual linearized transform.

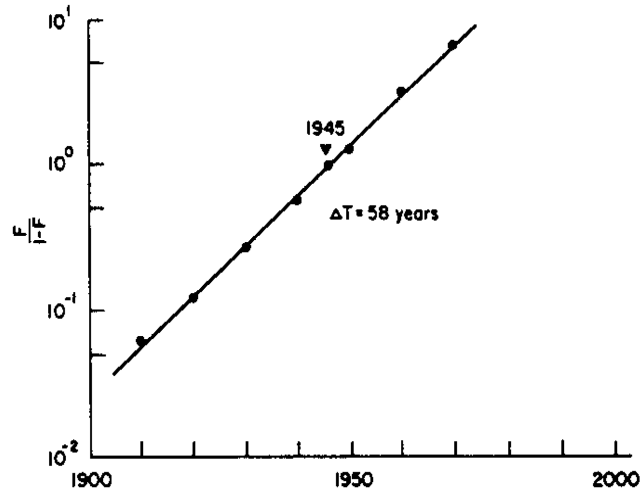

Figure 4. US surfaced roads (saturation point 3.4 x 10^6 miles). The development of the paved road network in the USA is shown here. The saturation point was never reached, and is calculated by fitting. Surfaced roads started well before the massive spread of the car. The rate of construction was already set when the car started penetrating, and was not modified thereafter. The causal link often assumed between car and road is certaintly weakened by this observation.

the sequence is airways. Representing all transportation infrastructures in the USA on a single graph (see Figure 6), we observe a reasonably organized sequence of pulsations separated by 50 years. From this we conclude that building transportation infrastructure is a resurgent activity; only the particular technology changes from pulsation to pulsation. At this point I am biting my nails while trying to guess what will be the technique for the next round. Vacuum tunnels plus magnetic suspension? Watch the Japanese for the hint. The starters should begin around the year 2000—a period that is in tune with Japan's intentions for magnetically suspended railways.

The energy system is also a form of infrastructure.[1] Similarly representing the world market shares of primary energy sources for the period 1850–2050, we

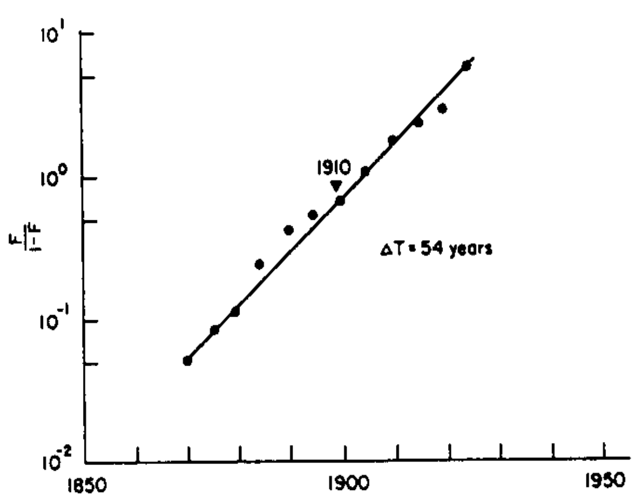

Figure 5. Western Union Telegraph length of wire (saturation point 2.3 million miles). Telegraph lines in the USA did also grow logistically in length with a saturation point around 2.3 million miles of wire. This length was actually reached in 1942.

The centrepoint, when construction activity was at a maximum, is in 1910. This coincides quite well with the centrepoint of the economic boom that was about 1914.

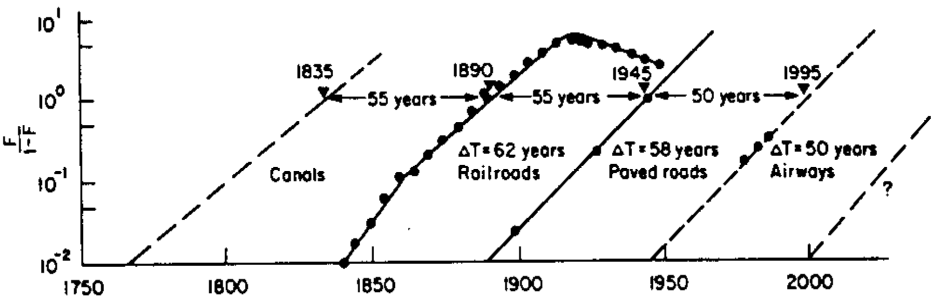

Figure 6. US railroads (3×10^5 miles); US paved roads (3.4×10^6 miles) and US federal airways (3.2×10^6 miles). If we take all transport infrastructures, measured by their length and elaborated through logistic fitting, we find a sequence of pulses whose centrepoints are spaced about 55 years apart, and whose time constraints are in the same order. I did not find reliable figures for the length of the canals, but only the period of maximum activity, ie the centrepoint. If the sequence continues, then the next infrastructure should start around year 2000.

find four starters—coal, oil, natural gas, and nuclear power. Each start begins about every 50 years. The time constant for the market penetration on the global scale is, however, in the range of 100 years—covering two pulsations. Thus wood, coal and oil can be said to be in their phase-out configuration, and natural gas and nuclear power to be still penetrating the market. A new start around 2025 would fit very well the hopes of physicists tinkering with fusion.[2]

A time to invent and innovate

Several years ago I analysed innovation waves.[3] The major results are shown in Figure 7. The lines indicate the cumulative number of innovations at a certain date and for a certain wave, expressed as percentages or fractions of the total

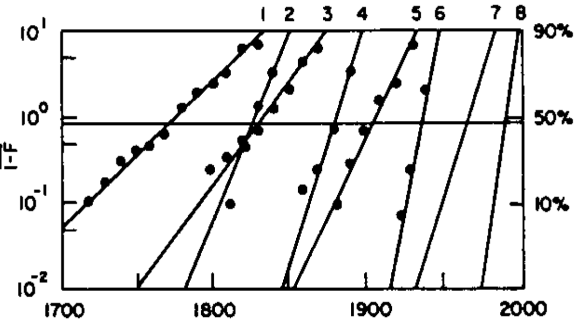

Figure 7. Invention and innovation waves—the secular set. Analysing basic innovations for the past 200 years, Gerard Mensch found they organize in three temporal clusters. Each cluster can be analysed logistically and the result is given in this Figure (lines 2, 4, 6). The centrepoints of these clusters are spaced about 55 years apart. A cluster n.8 can be constructed, describing the present wave of innovations and its immediate future. To start checking this forecast, one has to wait another ten years or so. Also the inventions which did precede the innovations organize in clusters that can be analysed logistically (lines 1, 3, 5). Line 7 describes the distribution in time of the inventions which will go into 8, but we have to wait for their success to be able to identify them.

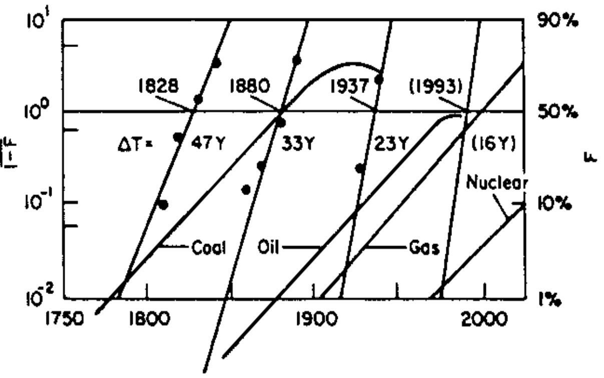

Figure 8. Innovation waves and the start of new energy sources. Innovation waves do not operate in a vacuum, and they do in fact correlate with almost anything. In this chart we show them in relation to the (logistic) market penetration of primary energies at world level. The starts of new primary energies correlate well with the starts of innovation waves. This is also true for the actual start of nuclear energy and the calculated start of the present innovation wave.

number in that wave. The centrepoints are separated by about 54 years, although there is a reduction in the time constant—ie there is a sharpening of the wave as one proceeds in time. These basic innovation waves represent the starters of new products and industries. They are of utmost importance in determining the level and the pulsation of economic activity.

Figures 8 and 9 provide an example of the complex interlinkage. Here inventions, world market shares for primary energy sources, energy prices, and detrended energy and electricity consumption in the USA are also reported on the same time scale. The tuning is remarkable, pointing to either causal links or common causation. A tentative analysis of the UK coal industry, using a sequence of logistic growth pulses, is shown in Figure 10.

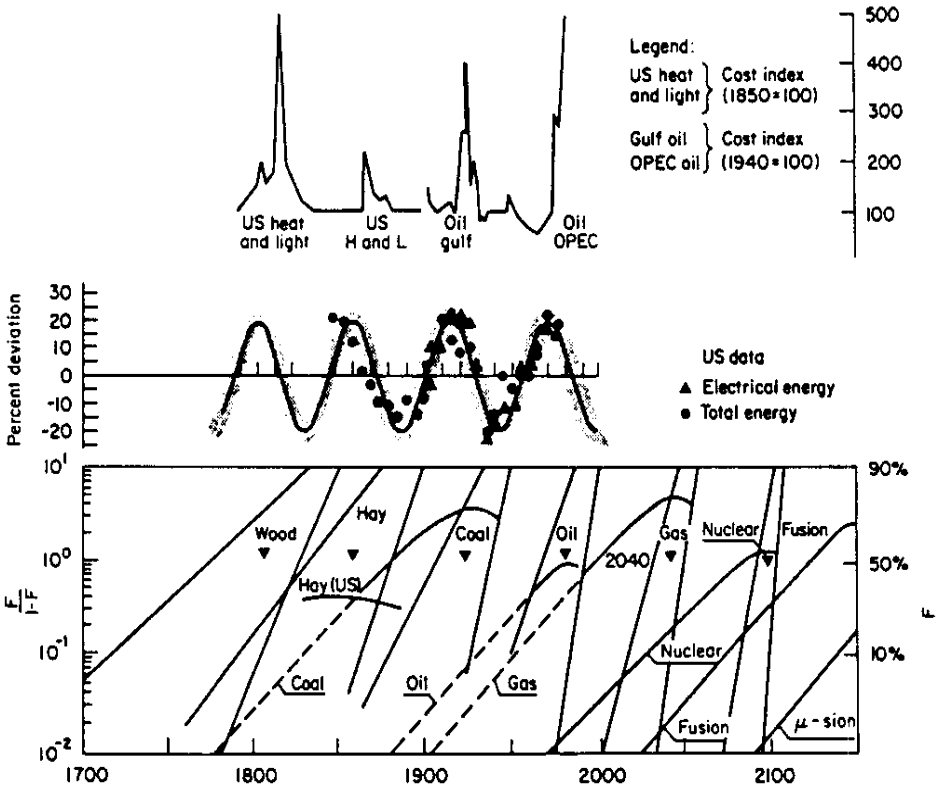

Figure 9. Invention and innovation waves—the secular set. This Figure shows even more correlations in the area of energy. The point in time when a primary energy reaches its maximum market penetration coincides with the centrepoint of an invention–innovation wave. The case of hay should not be taken lightly. It was the diesel fuel of the time. In 1850, two-thirds of the mechanical energy in the USA, including steam engines but also water mills and sailing ships, did actually come from horses. The sinusoid in the middle of the Figure fits the deviations from (logistic) trend of electrical and total energy consumption in the USA. It shows a periodicity of 54 years. The top part of the Figure reports the prices of energy as far as possible in constant money. The price flare of 1974 does not seem a unique occurrence. This analysis did show a logic (in 1979 [see *op cit* text reference 3])for a short-term fall in the prices of oil which is actually taking place.

A time to kill

Having sifted through hundreds of graphs and meditated on causes, I am strongly inclined toward common causation. As artists perceive and express, society is moody, protective, aggressive, enthusiastic, and depressed—individual behaviour is closely aligned. I received an initial hint in that direction from my recent exploration of societal aggressiveness. As indicators I used casualties for murder and suicide, the argument being that statistics on death are given more care than most other events. Specifically, the data for the USA provided a long and homogeneous time series. Delving further into the details, I looked at certain techniques of murder, as well as the male–female ratio of the victims. The results for murders and for suicides are reported in Figures 11 and 12, respectively. The 54-year sinusoid of the detrended energy consumption for the USA is also shown on top of each of these figures, in order to serve as a kind of reference clock and an indicator of societal activism.

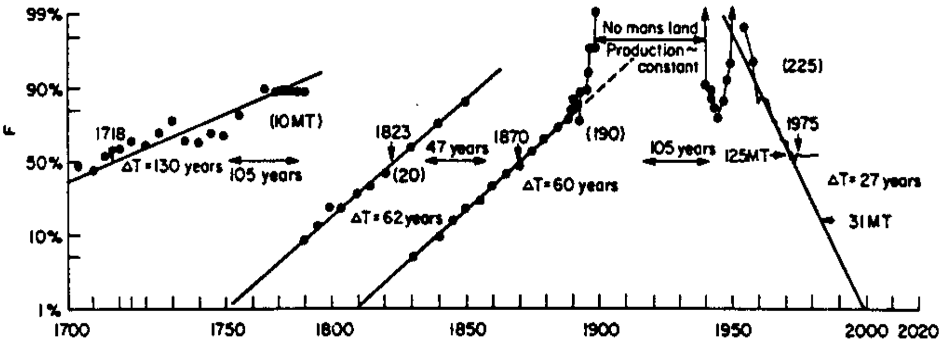

Figure 10. UK coal production (MT). This chart shows an attempt to analyse (splice) the history of coal extraction in the UK in terms of logistic spurts of growth. Every straight line represents a logistic as usual, and the number in parentheses tells how much it added to the previous level. The first period shows bad fitting and should probably be split, but I did not do it because the data are not too good and do not extend before 1700. The second and third spurt appear quite well shaped with time constants and distance in the range of 50–60 years. Between 1900 and 1950, in good coincidence with a full cycle, production oscillated around 200-plus million tons and the oscillations are too ample for this kind of ordinates. After 1950 production went down logistically and the trend was stopped at 125 MT by political intervention in 1975. Curiously, the strike in 1984 brought the production very near the level predicted by the equation.

The tuning appears to be very good with both advanced and retarded phases. For example, the maximum rate of homicides occurs at the centre of the recession branch of the energy wave, together I must add with the maximum mortality rates for enterprises, banks, and stocks. As for murder weapons, the use of firearms as a ratio to knives shows only a slight phase retardation with the energy (or activity) indicator. When business is flourishing people tend to shoot; when it is down, they stab. The signal is not a tiny ripple—the ratio between the maximum and the minimum is a factor of three.

Turning to suicides, we find a curious result—there is a 27-year pulsation in the ratio of female to male. This pulsation, in phase with the tops and bottoms of the activity cycle, corresponds to periods of high societal and international aggressiveness. Wars and revolutions, in fact, tend to cluster around these points. Perhaps one should look at the situation in countries where women are drafted.

A time to construct

The detrended oscillation in energy and electricity consumption incorporated in Figure 9 is an important indicator of societal activity. It is therefore highlighted in Figures 11 and 12, with a schematic version for use in checking the phases of certain activities described above.

Figure 13 again reports on the construction of Italian railways, but against a skeleton of the primary energy oscillation in the USA. Basically construction took place during recessive periods, although the starts occurred during the booms. This appears to be rational, since a recession implies capital and manpower in search of employment. Moreover, the times considered here were favourable to such capital-intensive and slow-profit enterprises. Perhaps the very intense spurt occurring at the end of the recession could be considered a

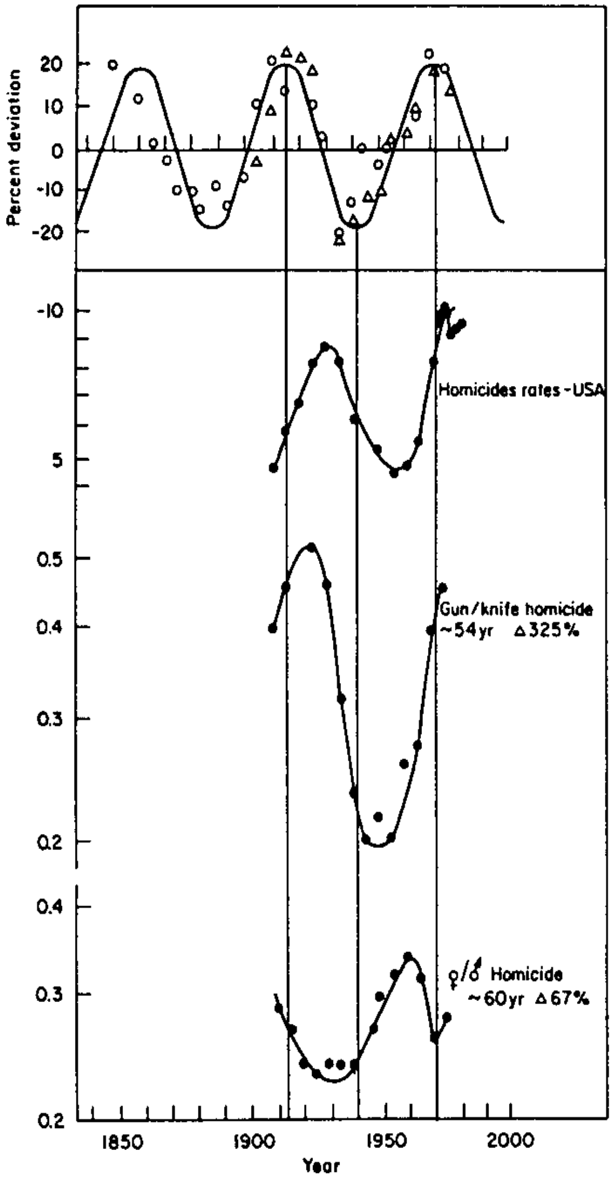

Figure 11. Homicides in the USA. To show that these cycles dig deep into social behaviour, the case of homicides in the USA is reported in this chart. The reason for choosing homicides is because their statistics are reliable and homogeneous. The upper energy indicator merely serves as a clock to position the facts against the general social activity. Homicide rates are expressed in terms of per 100000 population, and they appear particularly high for the USA. For a reference, car mortality accidents range to 25. The ratio between maximum and minimum rate is about a factor of two. Also the type of weapon used seems to be tuned, with people tending to shoot during a boom and stab during recession. Ratio of a factor of three. Finally, the ratio of female to male victims appears also to be cyclic.

planned move against the strong unemployment at the end of the century. Keynes before Keynes!

Figure 14 illustrates the position of the centres of the metro starter wave against the skeleton energy wave. Again, there is a tendency to *start* under-

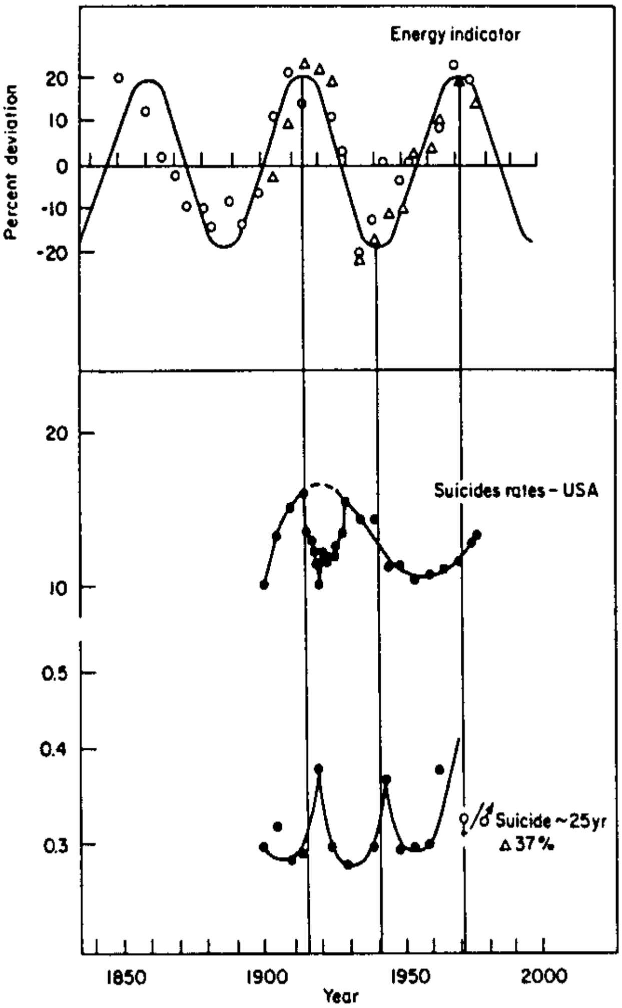

Figure 12. Suicides in the USA. This chart should be read like the preceding figure. Both homicides and suicides are obviously an expression of aggressivity inside a certain society and probably the most uninhibited indicators. The very curious observation here is the 27-year cycle for the ratio of female to male victims.

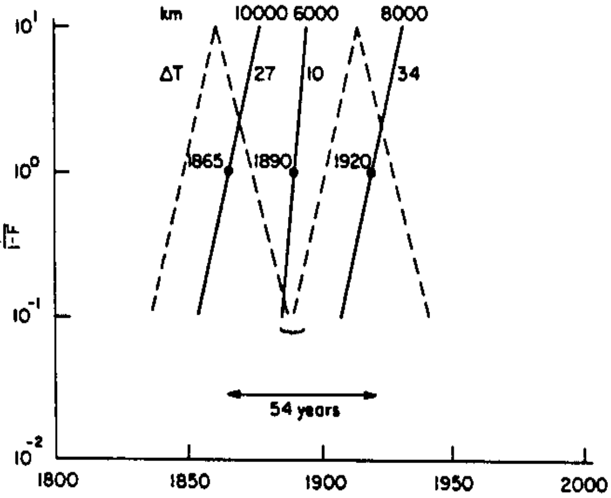

Figure 13. Italian railways construction spurts.

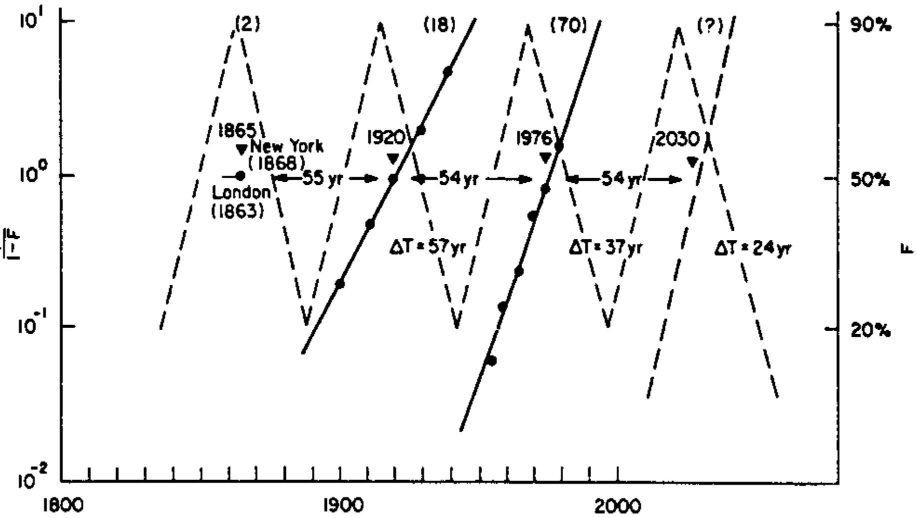

Figure 14. In order to position the various facts into the activity grid, as expressed by the energy indicator, I use a single zig-zag schematization of the fitting sinusoid. Line up means period of boom and dawn of recession. In the case of metros we see the centrepoints of the starter waves just after the end of the boom periods—meaning the starts are equally divided between boom and recession, but at the top. Further construction, however, mainly proceeds during recession. A particularly interesting case is that of Italian railways, where practically all construction occurs during recessions, with the 1885–1895 spurt just at the bottom of the recession period.

ground railways during recessive periods, including some part of the end of the boom. This would suggest that construction is mainly anticyclical.

As for the transportation infrastructure in the USA, the centrepoints of the deployment are at the very bottom of the recession. As the time constraints are about 50 years, this would suggest that the starts are at the end of a boom and that construction is shared between recession (during the first half) and boom (during the second half).

Conclusion

A pulsation of about 50 years pervades all sorts of human activity. I have the impression that the social communication system is the mediator of the signal and possesses a cooperative character, with no outstanding 'decision centres'.

This de-emphasizes the theory of a central cause of economic activity, making this activity just one of many manifestations of social information trading. As I tried to prove in a previous paper,[4] this trade follows strict biological rules. Within this context, an automobile is the transcodification of a conceptual structure in the same way that an animal is the transcodification of a DNA structure. Incidentally, automobile populations grow exactly like animal populations.[5]

By broadening the framework and avoiding the quicksands of money indicators, this de-emphasis may provide a simple description of economics as a social phenomenon. I am aware that this work is exploratory in character, which may serve to excuse the numerous shortcomings.

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Appendix

The data are fitted using the equation:

$$N(t) = \frac{\bar{N}}{1 + \exp - (at + b)}, \tag{1}$$

where

$N(t)$ can be the number of objects at a certain time t (eg railway nets for which the first line has been already inaugurated) or a certain measure of development (eg km of rail tracks).

$\bar{N}$ is the asymptote. If it is not known externally, it has to be calculated from the data by fitting.

a is a rate constant. In the charts I usually give an intuitive equivalent, the time constant. TC is the time to go from 10% to 90% of the asymptote.

b is a time cursor. It displaces the process in time.

In the charts a transform of (1) is normally used. By putting $N/\bar{N} = F$, we can write (1) in the form:

$$\log (F/1 - F) = at + b.$$