

Pervasive Long Waves: Is Human Society Cyclotymic?

Cesare Marchetti

*International Institute for Applied Systems Analysis
Laxenburg, Austria*

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HABITAT VERITAS

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Cycles are part of human activity. The daily cycle forced by sunlight is the most evident one. Via the pituitary gland, it penetrates into our hormonal regulation and general physiology. There is also the weekly cycle probably linked to the quarters of the moon. And the yearly cycle tuned to the movement of the earth around the sun, via its inclination over the ecliptic. These cycles, all of celestial origin have a profound modulating effect on human activities and behavior, sometimes down to tiny details.

In the twenties, Kondratiev perceived a much longer cycle, about 55 years, emerging from his statistical time series. On rereading Kondratiev papers one feels mental rigor, intuition, and great reliance on factual data, against prevailing theories if necessary. Kondratiev theory, since the beginning, was seen with malignant eyes by the economists of all denominations. It is a common tenet in economy that man is a rational operator endowed with free will. This mega tide, coming from nowhere and overcoming all possible defenses, was absolutely against the grain and had to be stamped out as a mephitic alien.

I stumbled into Kondratiev when making an occasional study on invention and innovation timing. Because I am a physicist by education I did not have a pre-set mind. Furthermore, through my numerous and quantitative analyses of the social system I had acquired the certainty that basic instincts are more important than free will in determining human behavior, including the economic one. So I went on in the direction of Kondratiev searching all empirical evidence on pros and contras.

The results of my endeavor are, in a nutshell, that Kondratiev cycles

penetrate all strata of human activity. Even the choice of gun or knife when

committing a homicide. And that all explanations given by economist pro Kondratiev, starting from Schumpeter are basically false, even if something can be saved here and there. It must be clear that I did not find an interpretation satisfactory to me. But I may describe *the cycle as an up and down of moods*. Oscillating more or less sinusoidally with a complete cycle of 55 years.

During the first half of the cycle, people are in a greedy position. Formally they buy. Whatever is at hand. The economy blossoms and expands. During the second half people become prudent and mean. They reduce buying almost to a stop. They save money and sterilize it into government bonds. This money is never retrieved. During the first half of the next cycle they start again buying the things they stopped buying before (e.g., cars) showing that market saturation was not the cause of sales saturation.

The *retreat of the buyers* has many consequences on the structuring and operation of an industrial society. In a more or less competitive system, efficiency in production, i.e., productivity is one key tool to overcome the competitor. Now for mysterious reasons, increases in productivity tends to hang around 3% per year. This figure is open to discussion. I use it to proceed with my argument. Productivity can be measured, e.g., in man-hours to make a product, e.g., a car. Then if car sales increase more than 3% per year, the car industry will absorb manpower. If they increase less, it will excrete manpower. To stay with cars, world production has been constant (around 33M) during the last ten years, during which that industry has excreted one-third of its work force.

presses the system, the problem of jobless people becomes soon macroscopic. The normal palliatives consist of picking money from the pockets of the savers, and distribute it, “socially”, to people that in a way or another produce nothing. A second mechanism consists in operating internationally, and lending money to the poor, which – needing everything – are in a greedy state round the clock. These lendings are wrapped in financial formalisms, but it is not necessary to be cynic, to understand from the beginning that the money is given. When the evidence becomes overwhelming the process stops as I will show. Obviously this money comes back (or should) to buy products from the lender, so reducing the rate of his lay-outs.

We are now between the end of the cycle, and the beginning of the next. However, fording across minima is a flat process and the natural recover may come too late, when the overstressed social economic system will have already broken. This happened by the way toward the end of all preceding cycles. The cost of paying the non-producers (solution 2) is becoming unbearable by the pockets of the producers. On top of the fact these paid non-producers often are not featherbedded inside institutions but explicitated, which ruins their morals.

If I had the task to make a constructive proposal following a hint from Schumpeter, I would try to revive solution 1, which has the added advantage of helping the poor in the vast lowlands of the semideveloped world but changing it from a fully-fake financial procedure to a half-fake commercial proposition.

The developing countries often provide raw materials to the developed

less prerduced). The corresponding industries are depressed because of the recession in the developing countries. Meaning they have a lot of overcapacity.

The developed countries could buy these materials *and stock them* (for the next boom). Developing countries should buy in exchange manufactured products from the developed ones. The financing should come initially from the dolc money, as the purchased produces (with some delay) would reduce unemployment. Later on, one could monetize the stocks through some ingenious financial instrument, inventing, e.g., “hard futures” where the bet is done holding the bird in the hand.

I think that *with determined driving forces* the mechanisms could work, and relatively fast, although the scale of operation is huge. Just to give a flag number, 100 billion DM is the monetary unit. To start having an effect. For Germany. Obviously a complex and clever organization should be set up to run the intricate machinery of the operation. For the 10 to 15 years to cross the ford. The only institution with some of the necessary characteristics, if not the necessary world breath and territorial penetration, is the Treuhand that operated fairly well the recapitalistization of Eastern Germany.

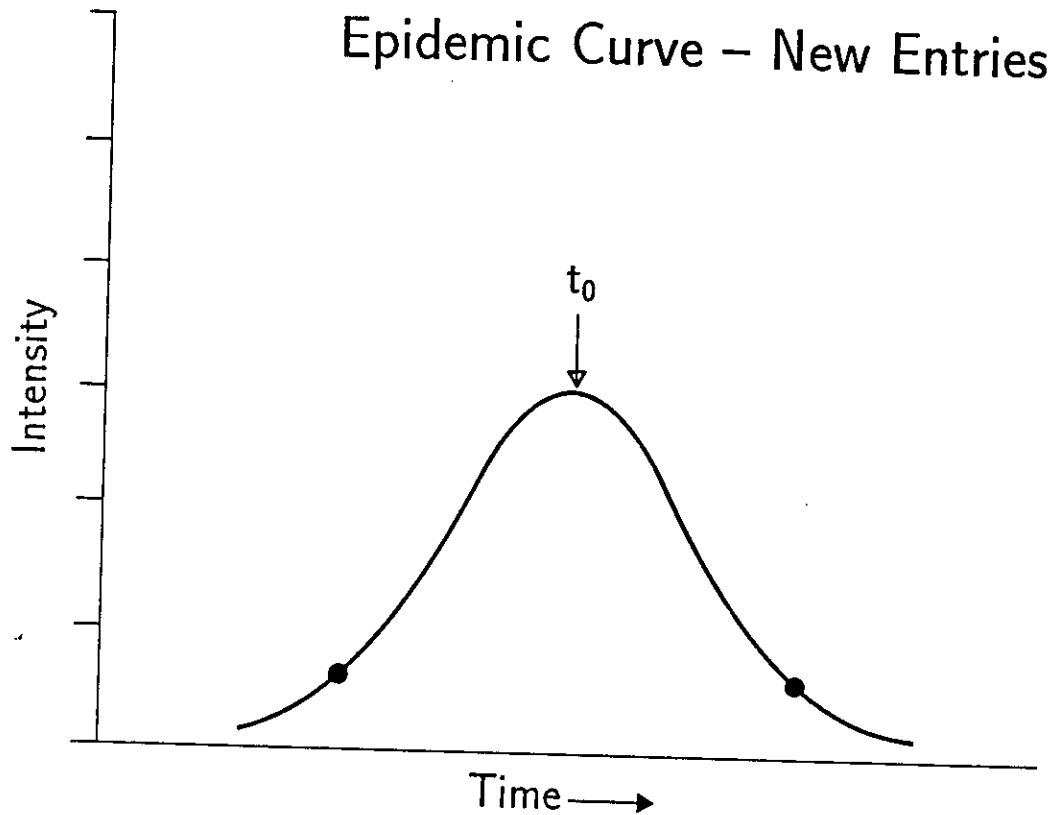
I indulged in suggestions to reduce the jobless because this is the objective of the conference, but I am now coming back to my more familiar modeling. The boom is fueled not only by the re-started desire to buy old things (e.g., cars) but also by a flurry of new gadgets invented during the preceding boom and implanted into the productive system, with magical and providential timing, toward the end of the recession and the beginning of the boom. So the fresh greed will find not only more of the

same, but much, much more. Pleasure is also in variety.

One might think that inventions and innovations, the fuel of progress, come down stochastically from heaven, and perhaps hump here and there without order. In the occasional study I made in 1979, I showed in fact that the process is rigorously ordered, can be modeled and predicted, showing that presumably the “system” is in control of the free wills of inventors and entrepreneurs, manœuvring them à la carte.

My conclusions are realistic and possibilistic. I think it is not the case to fiddle with the moods of the system. But I think also that the system is highly structured and one can take advantage of that, as I have tentatively proposed, to smooth out some of the nasty consequences of the moods, e.g., unemployment. It will, however, require clear minds, determination and faith.

The quantitative side of my consideration is developed in the following charts and they will complement the text.



The core of my modeling efforts, now summing to more than 3,000 cases worked out, is based on the assumption that ideas diffuse “epidemically” and *so do the actions linked to them*. The above curve may represent the diffusion of flue, measured in terms of new cases of flue, per unit of time. It also represents the lifecycle of a product if in special circumstances. Integrating over time this equation one obtains a logistic equation, summing up all flue cases up to a time t . My work shows that the *social and economic operation of our society can be decomposed in a very large number of sub-diffusion processes* summing up into an almost inextricable whole.

Quarterly sales

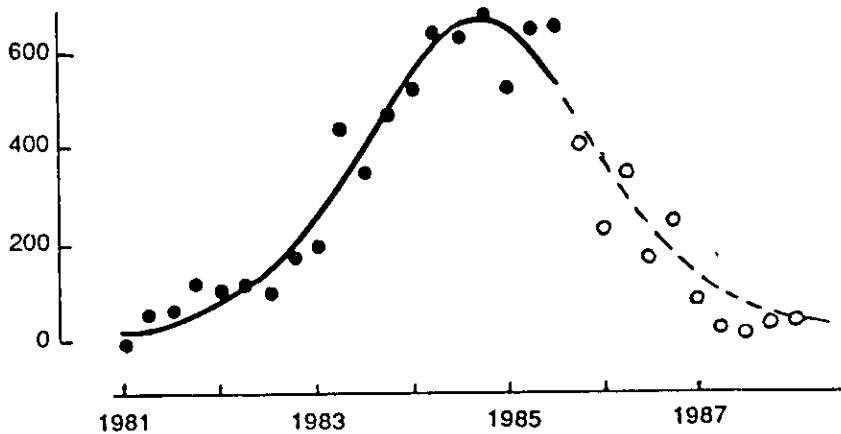
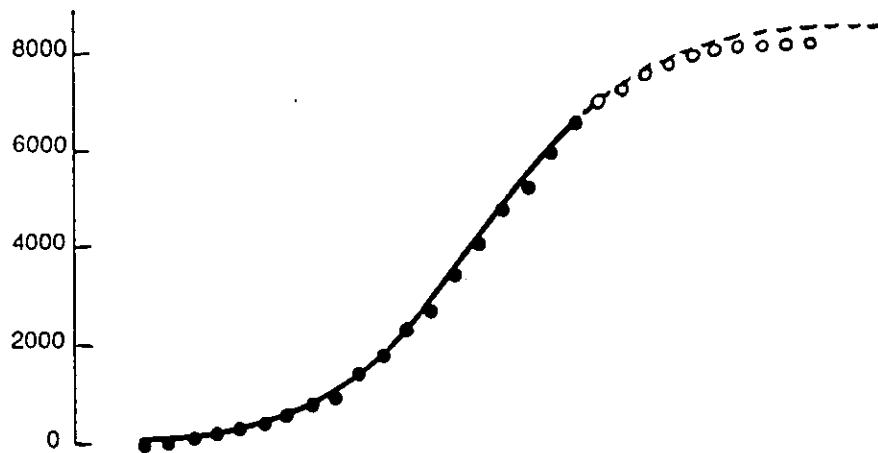


Chart 1

Cumulative sales

Chart 2



The chart on top shows a practical application: the quarterly sales of a new computer model by Digital. The lower chart shows the total sold as a function of time. The integration cancels out some of the noise in Chart 1, which is due to small anticipations or posticipations in the purchase. As we have witnessed in thousands of cases *these diffusion processes are usually very stable*, so that fitting part of the process with an equation can be used to *forecast*. Dashed lines are forecast, and open circles show actual sales in the forecast region.

Figure 2.

The Mathematical Methodology

The mathematics used in this analysis is extremely simple. The basic concept that *action paradigms* diffuse epidemically, is condensed in the epidemic equation:



$$dN = aN(\bar{N} - N)dt$$

saying that the number of *new* adopters (dN) during time dt is proportional (a) to the number of actual adopters (N) multiplied by the number of potential adopters ($\bar{N} - N$), where \bar{N} is the final number of adopters.

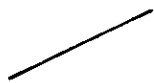
The integration of this equation gives



$$N = \bar{N}/[1 + \exp -(at + b)]$$

which is the expression of a logistic S-curve well known to epidemiologists and demographers. *We apply it to ideas.*

In the charts of the present paper the logistic equation is presented in an intuitively more pregnant form. N is measured in relative terms as fraction of \bar{N} ($F = N/\bar{N}$), and the S-curve is "straightened" by plotting $\log(F/1 - F)$ (Fisher-Pry transform).

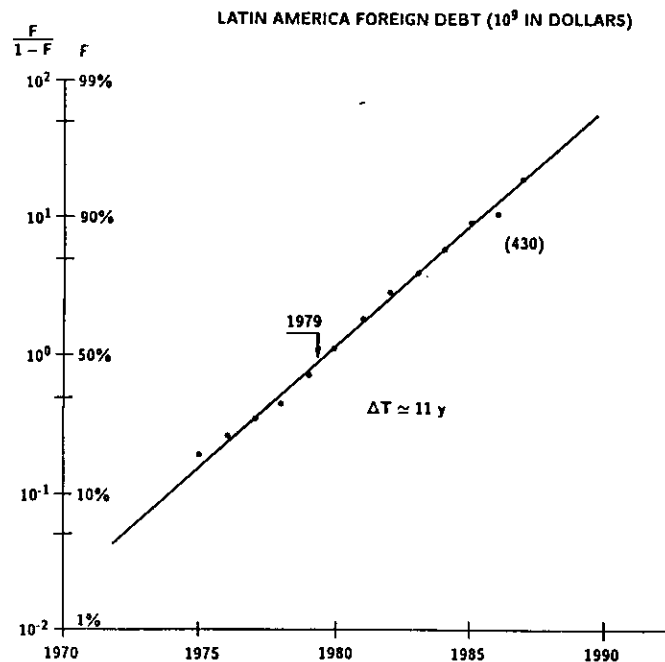
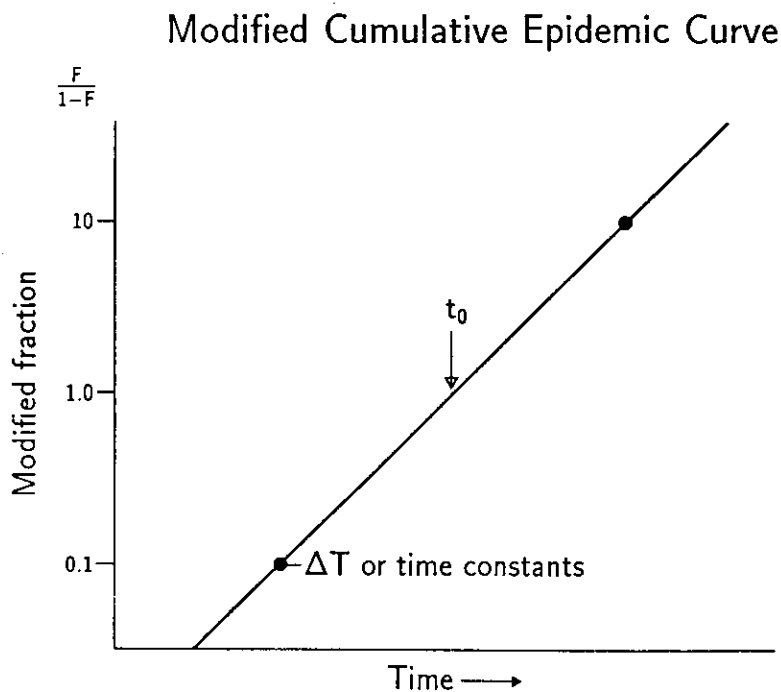


$$\log(F/1 - F) = at + b .$$

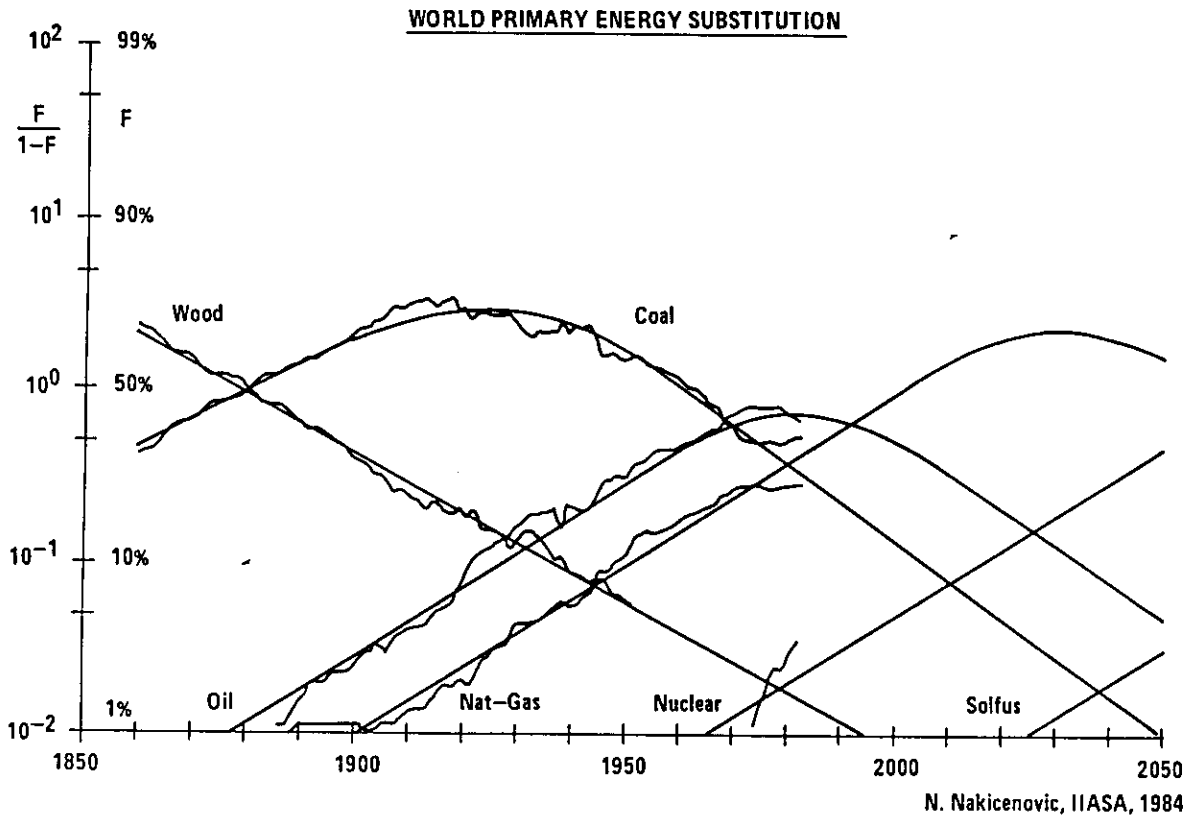
The time constant ΔT is the time to go from $F \simeq 0.1$ to $F \simeq 0.9$. It takes the central part of the process (80%) and the relation between ΔT and the a in the equation is $\Delta T = 4.39/a$.

The central date T_0 is defined as b/a .

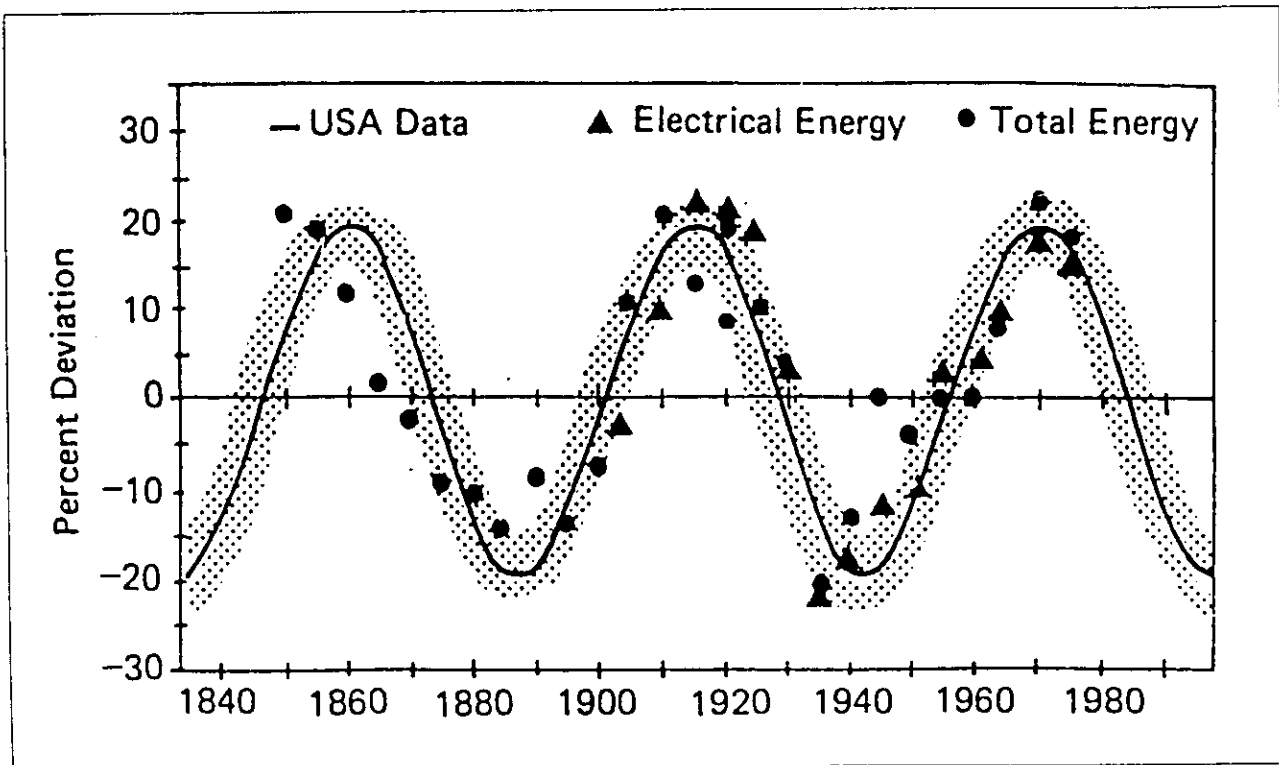
The final number of adopters \bar{N} is given as a number in parenthesis.



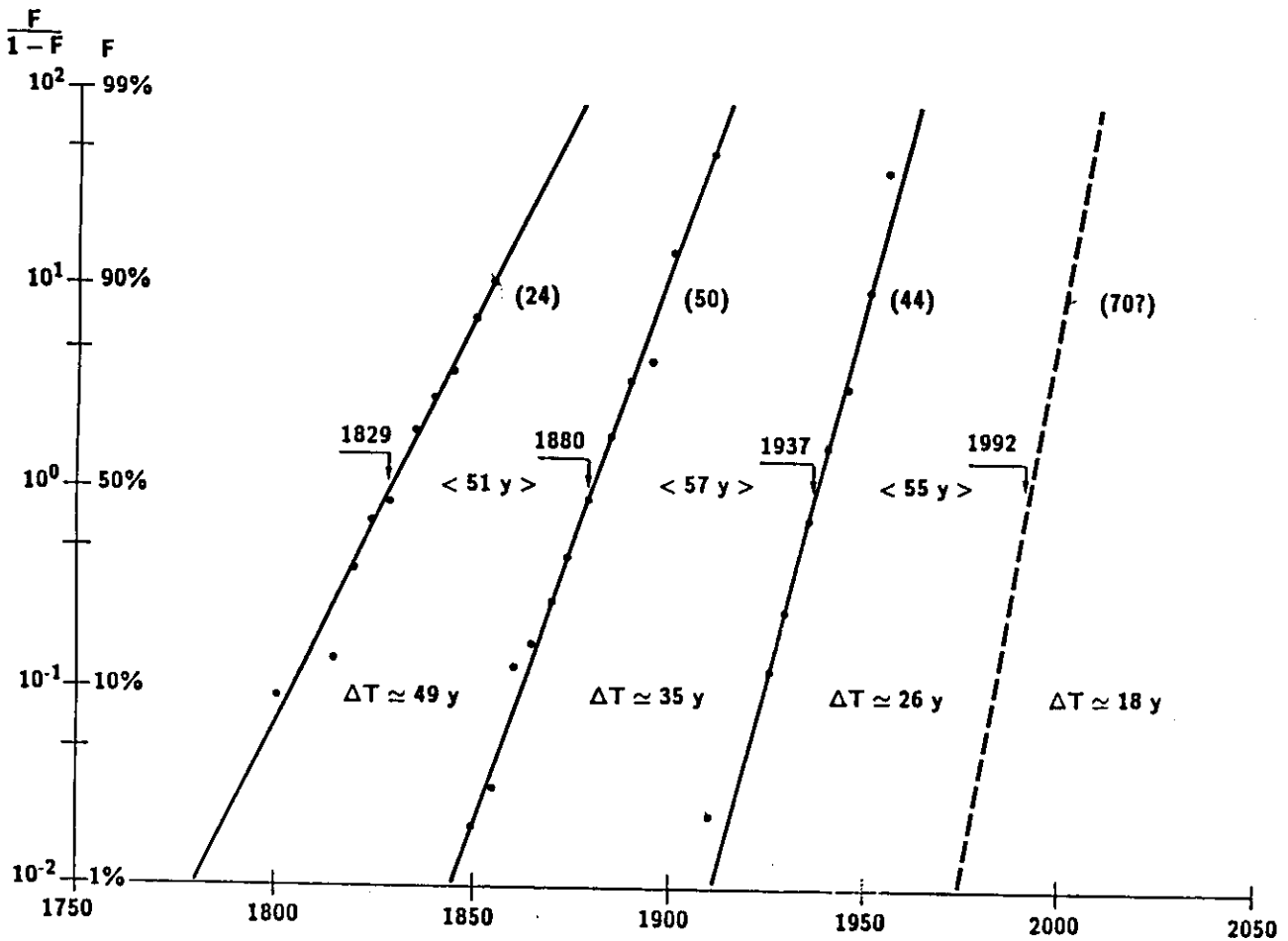
Most of the charts containing logistics are presented in a transform (Fisher-Pry) that linearizes the S-curve. This greatly simplifies the making and using of charts. The one on the right shows already an application of diffusive analysis, the evolution of South American debt in constant dollars. The figures represent the middle point of the process when the logistic reaches 50% of the saturation value ($t_0 = 1979$); the saturation value (430×10^9 \$) and the speed of the process, ΔT , measured as the time distance between the points where the logistic reaches 10% and 90%, respectively, of the saturation value. As we will see, the Kondratiev recessive phase spans the period 1968–1995, so the money has all been lent during recession. The fitting of data and equation (the black line) is remarkable, but it is most often so.



Life is rarely simple and competition tends to occur in crowded niches. Contrary to previous examples where the process of penetration was isolated or could be isolated, here we can look at competition in full color between primary energies for the world energy market. Market shares are reported, again in the F&P transform, over about a century and a half. The full lines are a system of somehow modified logistics and the wiggly lines the data. For each competitor only *two parameters* are sufficient to define its equation. Such a parsimonious mathematical equipment can fairly precisely describe – over such a long period of time – such complex systems as the world energy markets. Remarkable is the stability of the underlying process over so mutable political, technical, and social constraints.



Between the numerous indicators of periodicity in the economic and social system, I like this one for its clarity and directness. Energy and electricity consumption are very synoptic indicators of socioeconomic metabolism. This oscillation has been extracted from the curves of energy and of electricity consumption in US, by first fitting them at best with an exponential (better a logistic equation) and then looking at the residual. They represent accelerations and decelerations by respect to the secular trend. The upgoing branches are mirrored into periods of boom, the downgoing of recession. Obviously, the recession is worst toward the bottom. *I define recession as the period when productivity increases faster than production, and the system then sheds (real) jobs.*

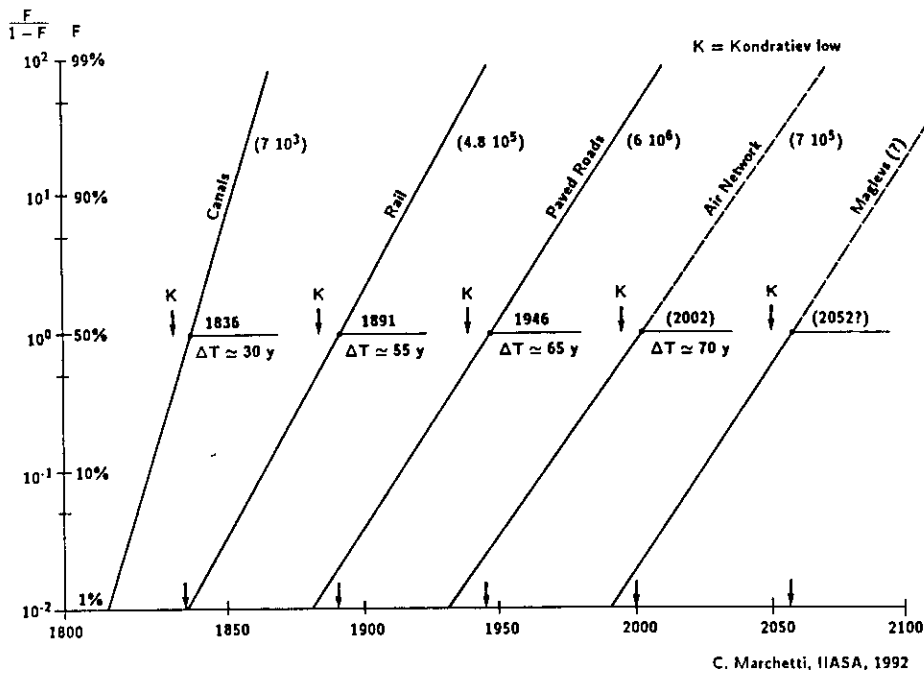


Basic innovations are the primary fuel of progress providing the system with brand new products. Starting a new industry (basic innovation) is a question of guts, luck, drive, blood, and sweat. Many are called, but only about 1% are finally chosen. One could expect perfectly random features, but on the contrary the process is extremely well regulated and selfconsistent over the centuries. What is reported here is the cumulative number of innovations which separate into three logistic waves, centered in 1829, 1880, and 1937. Internal consistency permits *to calculate* a fourth wave, into which we are living now, centered in 1992. The analysis is done through success, so we have to wait a few years to fit the curve with data. Some candidates are given in the next figure.

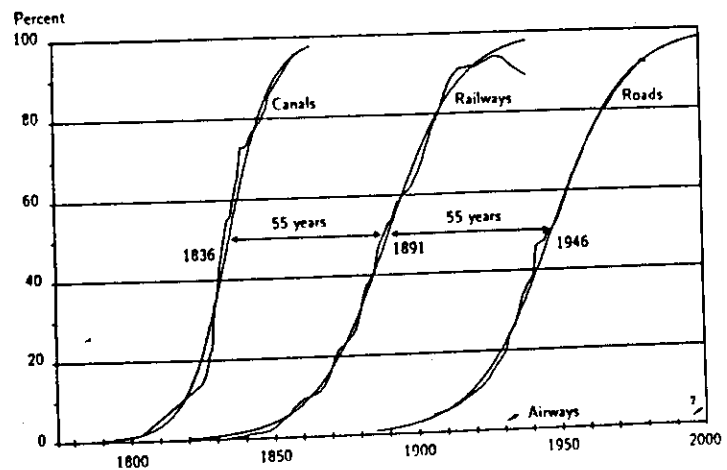
POSSIBLE CANDIDATES FOR FINAL SUCCESS IN THE PRESENT

BASIC INNOVATION WAVE

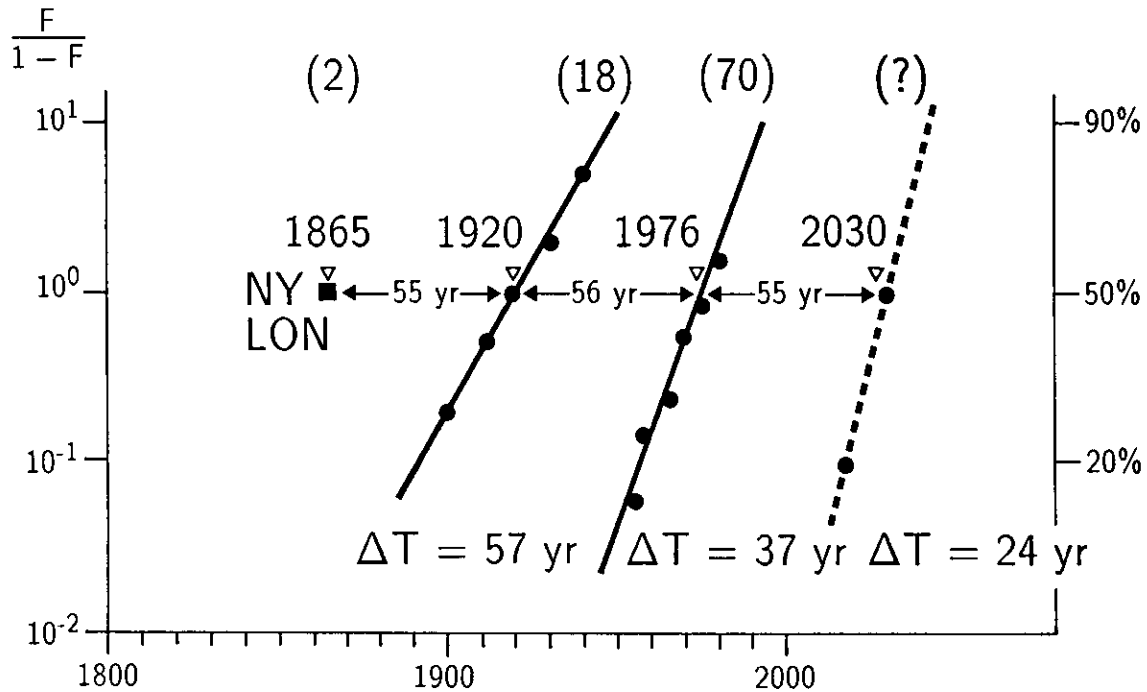
Mechanics	Tunneling machines Laser machining	Robot assembly lines Robot machining	Fly by wire Fly by light
Info transp.	Coaxial cables Optical fibers	Satellites Cellular tel.	ISDN Fax
Info process	Supercomputers Laptop computers	Desktop print. Xerox	Comp.disk Liq.crist.TV
Info gather	X-ray tomogr. Mag.res.tomogr.	Reading mach. Listening mach.	ERTS satell. Side-look radars
Materials	Synth.diam. Titanio	H ₂ -metals Supermagnet	HT-superconduct.
Chemistry	Gentech		
Services	Credit cards Bancomats	Bar codes Electronic clocks	Gentech Just-in-time
			Disassembly lines Telephone cards



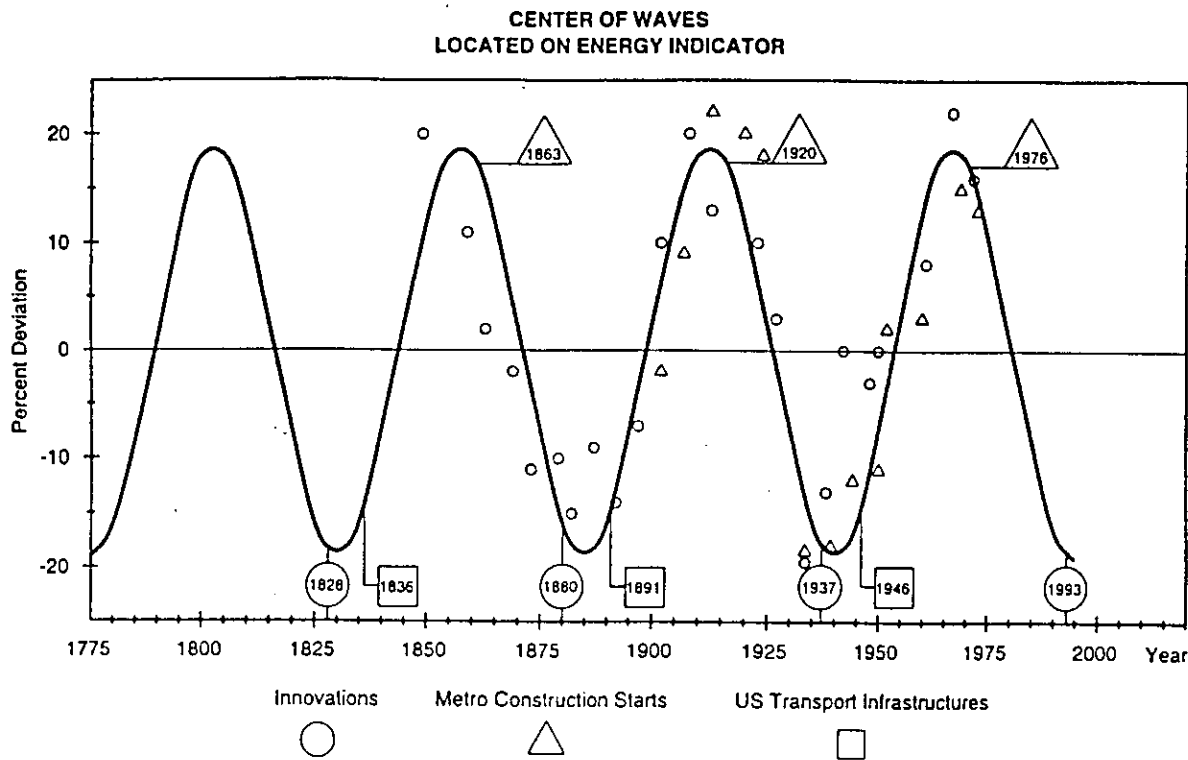
Innovation may appear a “soft” indicator, as there can be bickering about definition and measurements. About the length of canal or paved roads, there is almost no room for alternative views. The raw data expressed in percentage of final length, appear as in the window below (fitted with logistics). The complete display, including forecast, is reported above, in F&P transform, and without the data to keep the chart readable. As the window shows, a single logistic fits perfectly the data for as long as 100 years (paved roads). The Ks with a descending arrow indicate the points where Kondratiev cycles reach minima.



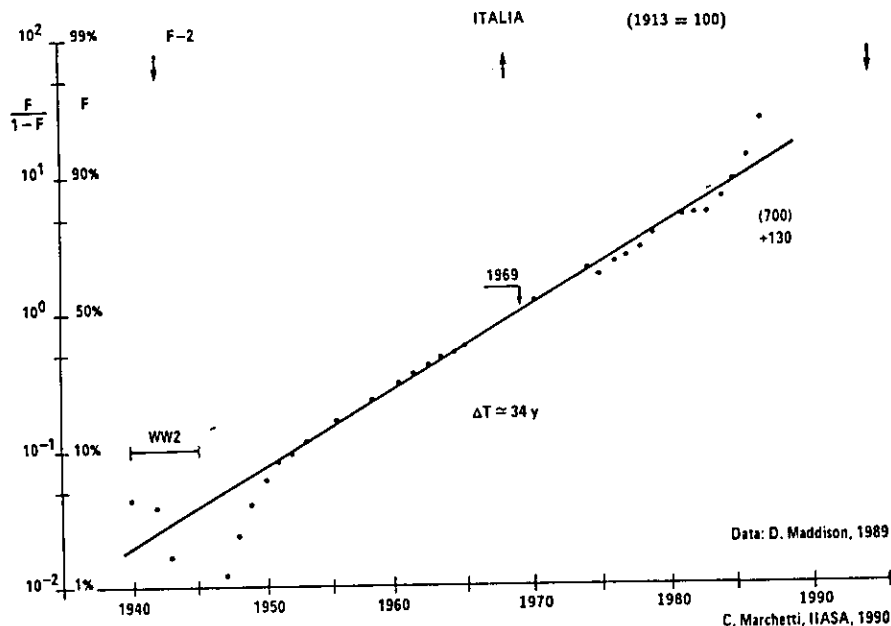
“Metro” Starters – World



In an experiment to match macroactivity to Kondratiev cycles I looked at the diffusion of metro systems around the world by counting the cities who had at least one line. Integrating that in time we have three waves of constructions, separable as independent logistics (the first one reduced to a point, as NY and London got a metro almost at the same time). The positioning of these waves in the Kondratiev system is shown in the next figure.

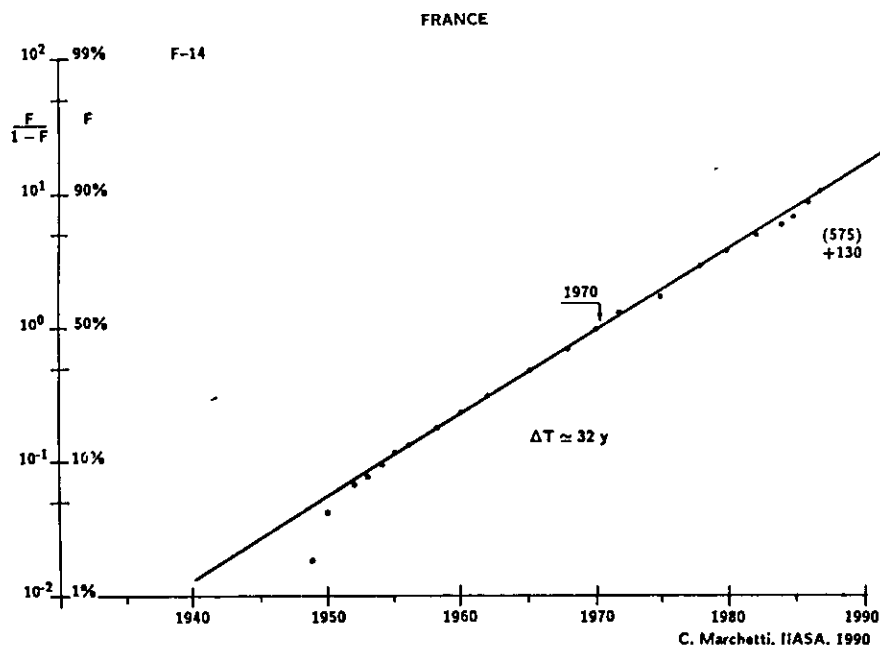


The three examples reported before, *innovations, metro construction starts, and US transport infrastructure*, reveal a pulsed activity, somehow reminiscent of Kondratiev cycles. In this chart, the main oscillation is again from the US demand analysis as in Figure 6. To that, the *centerpoints* of the logistics describing the three processes mentioned are reported. The absolutely striking fact is that the *system operates like a clockwork*. The said centerpoints fall into specified positions in the (Kondratiev) cycle with the precision of *one year*. E.g., infrastructures construction waves are always centered *six years* after the bottom. The system seems to know (50 years ahead) that public works are needed to overcome recession. The agitation of the decision makers seems to be of no consequence, because no ripples appear in the long-term equation describing the process (lower chart in Figure 9).



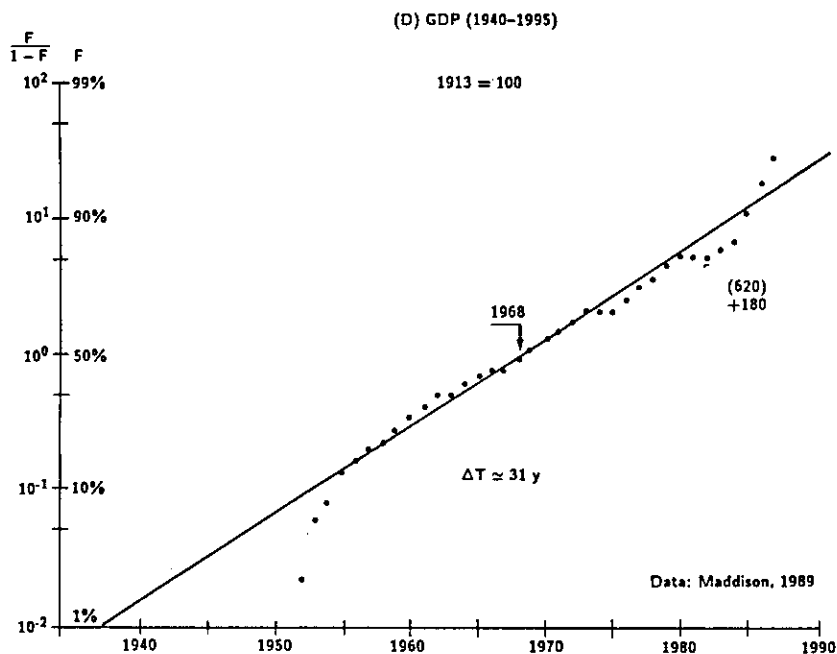
Italian GNP in constant money. GDP in 1940 ~130 (1913 = 100). Maximum rate of growth in 1969 (centerpoint).

Like energy, GNP is a synoptic number for the activity of a nation. Like energy may move, presumably, in tune with Kondratiev cycles. The centerpoint of our cycle is 1968, as deduced from US energy oscillation. Here is 1969 for Italy and 1970 for France. Taking into account all the imprecisions in the indicators and the fitting procedures, the coincidence is really remarkable. I just observe that wars make finally no difference, all losses are mopped up. Logistic fitting.



French GNP in constant money GDP in 1940, 130 (1913 = 199). Maximum rate of growth 1970 (centerpoint).

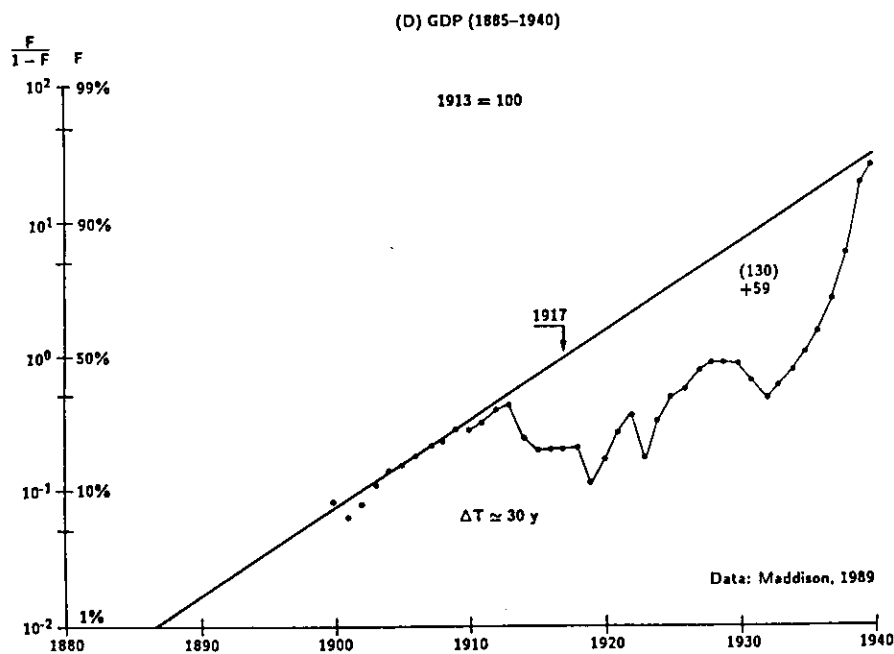
Figure 12.



GNP for Germany in constant money for the period 1940-1995 (1913 = 100). 180 is reported from 1940 and the increase is 620 centerpoint 1968.

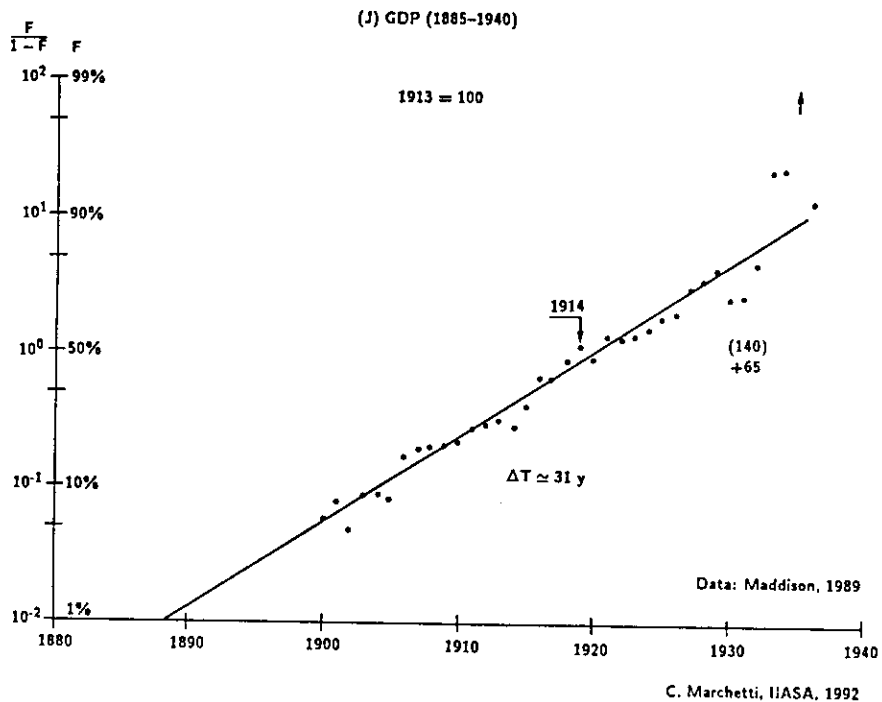
As in the case of France and Italy, also for Germany there is a very precise synchrony of the development of GNP and the Kondratiev cycle. Actually the centerpoint of US energy wave is in 1968. Underneath the same mapping for Germany in the previous Kondratiev. The disruption due to World War I is overly evident, but the expected value was finally recovered at the moment of restarting a new one, World War II.

GNP for Germany in constant money for the period 1885-1940 (1913 = 100). The blow of World War I was really heavy and recovery wobbly. World War II was on the contrary reabsorbed very swiftly, as most nations have done.



C. Marchetti, IIASA, 1992

Figure 13.



Logistic fitting of Japan's GNP in constant money from 1885 to 1940. The centerpoint of this cycle is in 1914, in strict accordance with the GNP centerpoint. Japan had obviously no problems with World War I.

As we have seen in the last three figures, the effect of the Kondratiev cycle on GNP is overwhelmingly present. The logistic curve representing the process grows as an exponential (almost) till the middle point and then slows down progressively to a full stop (saturation) at the end. As said in the text, unemployment appears in this second phase (recession and sometimes depression) because increases in productivity beat increases in production automatically reducing the need for employment.

Logistic fitting of Japan's GNP in the present Kondratiev cycle. The oil shock seems to have robbed some GNP, with full recovery in 1980. Very remarkable the $\times 10$ growth from 205 to 2650 (in 1913 = 100 units).

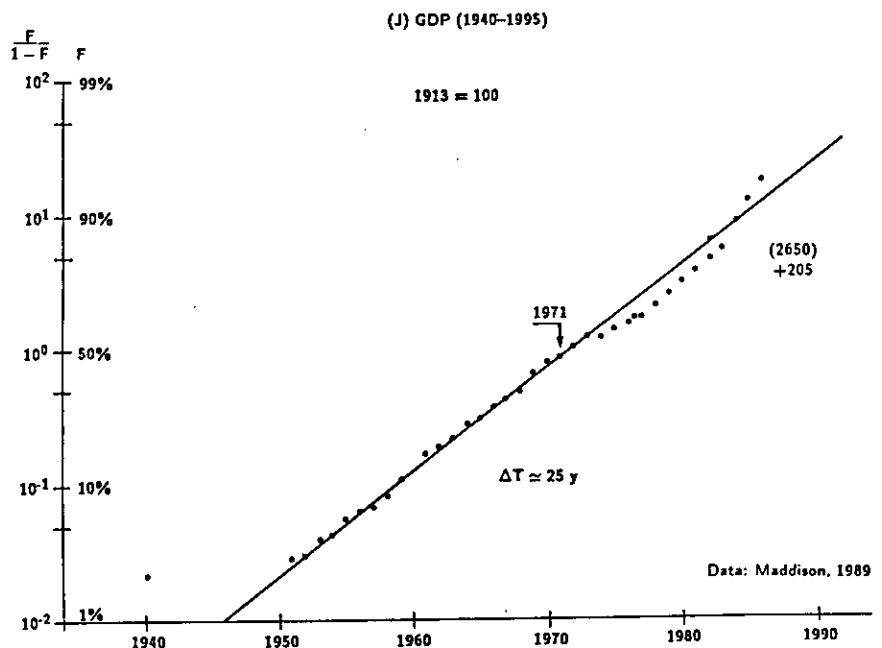
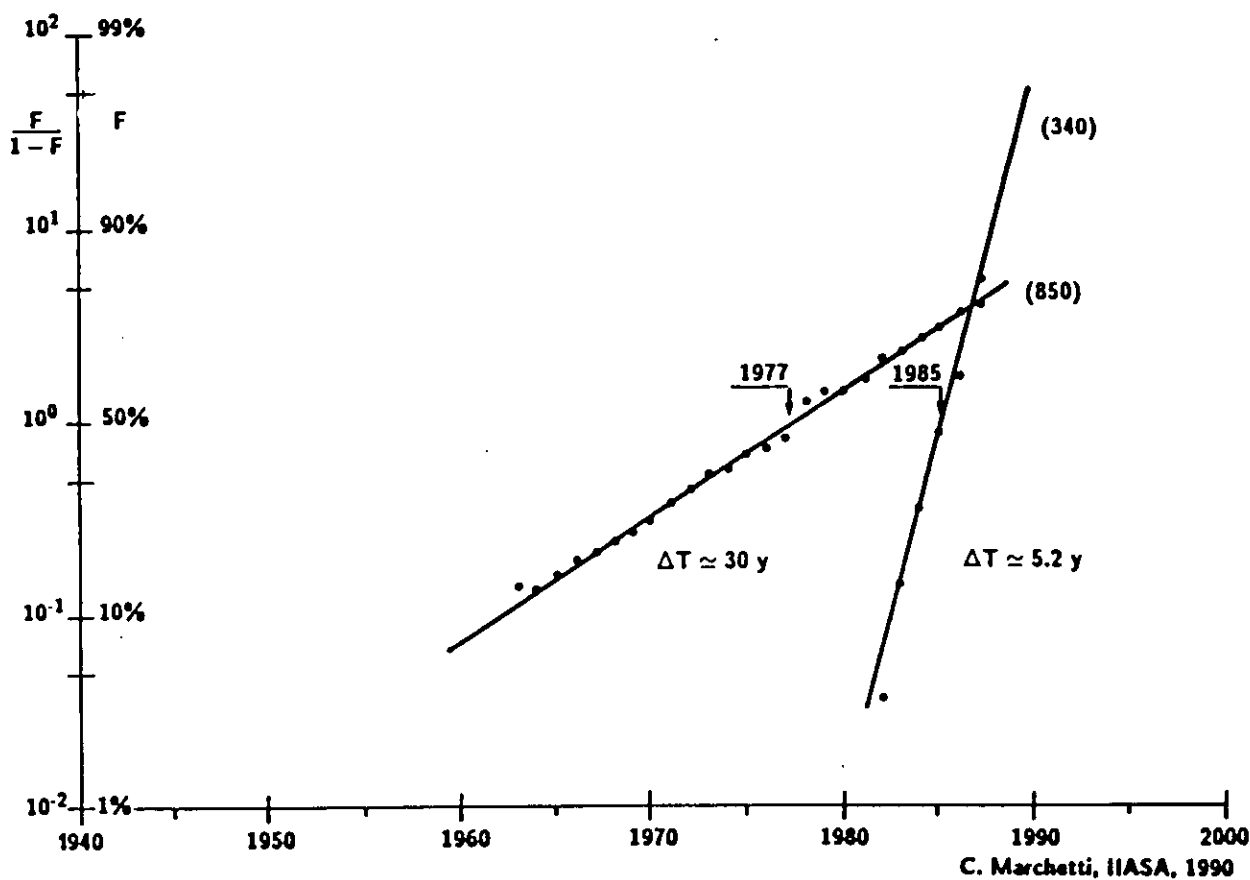
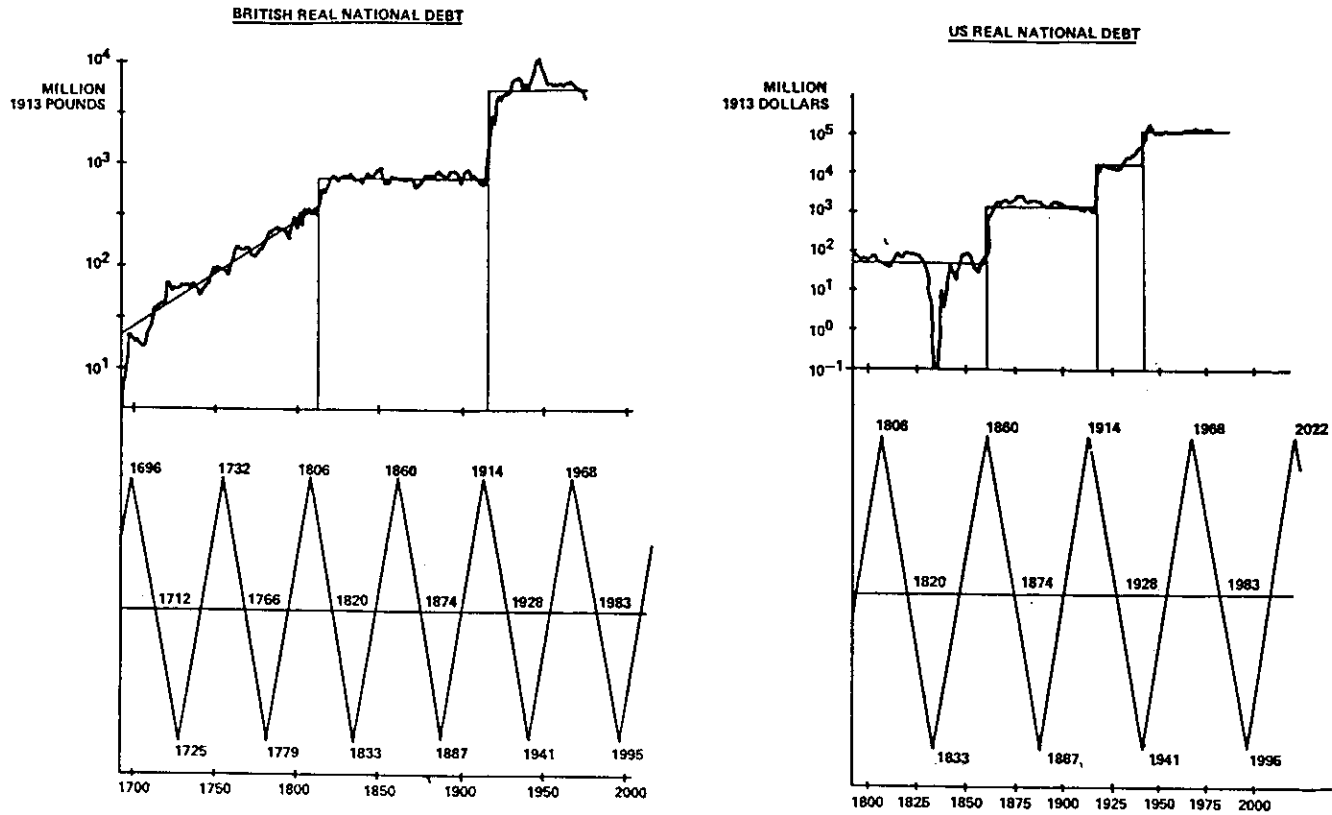


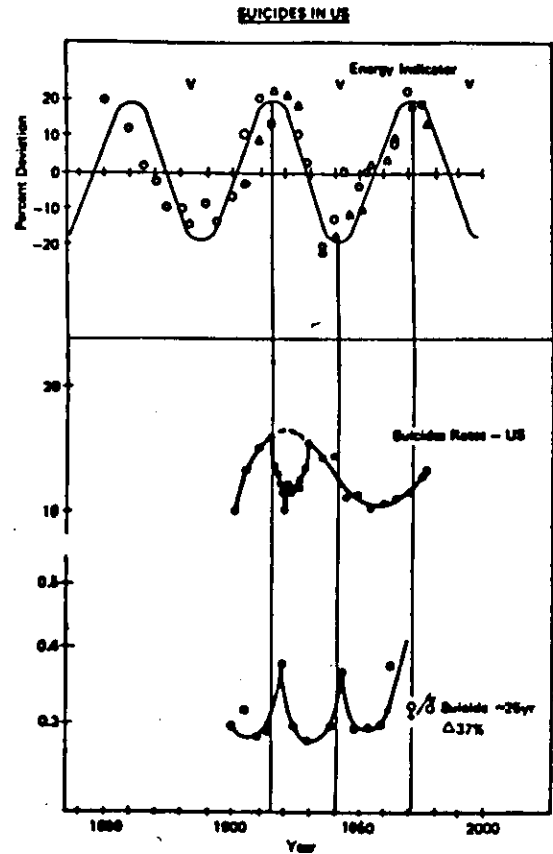
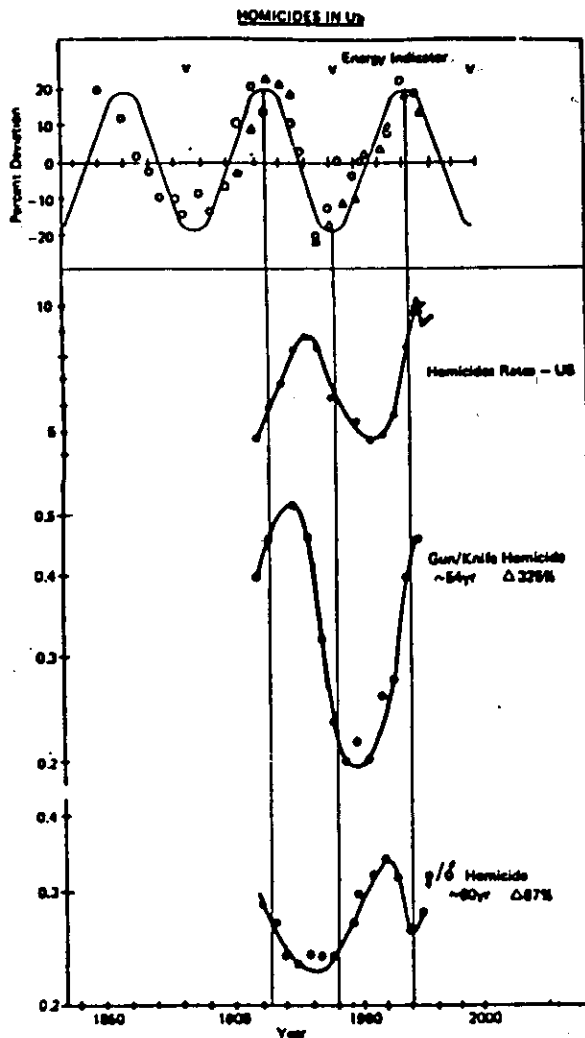
Figure 14.



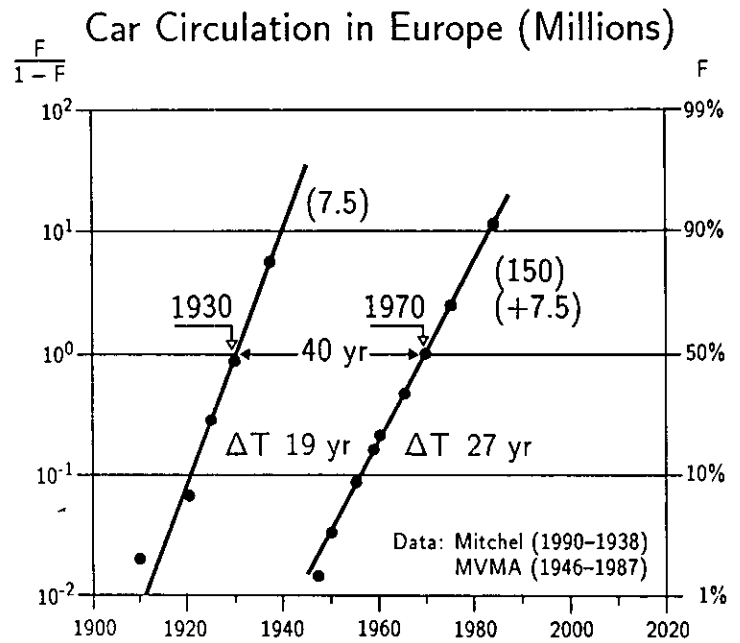
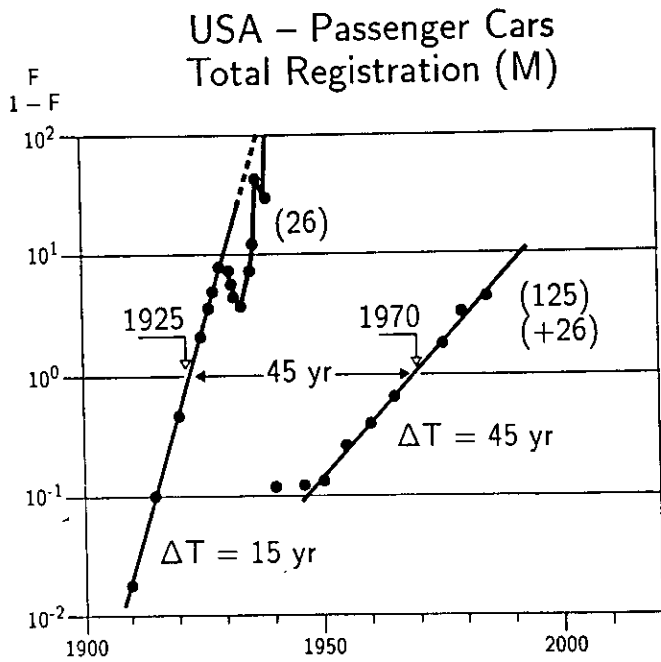
When facing recession, governments behave in an extraordinarily homogeneous way. Novel Robin Hoods, they take from the savers to give to potential spenders. The process always existed but was nobilitated by economists calling it “deficit spending”. The chart shows that Italian government started early in picking Italian pockets with a first (logistic) go centered in 1977 and leading to an integrated debt of 850×10^{12} lire (1989), followed by a second logistic centered in 1985 and summing up to 340×10^{12} lire (constant, 1989). Both of them saturate toward the end of the cycle (1995). $840 + 340 = 1190 \times 10^{12}$ lire are more than one year of Italy’s GNP. The great mystery is why the buyers of Government Bonds did not spend that huge pile of money just to enjoy life.



My invitation to enjoy life, let greed be free, and keep the economy on high tours, was done tongue in cheek. The sad point is that this money never comes back into the pockets of the savers. Italy and others have done that through runaway inflation. But serious countries like the UK and US do not fare much better. As one can see in the above charts, their debt in constant money always went up (with one exception, considered a basic mistake, in US, rapidly mended). The possibility of running this kind of show is linked to the hypothesis of an increasing GNP, finally belittling past debts. The situation is similar in the international area. South American debts depicted in Figure 4 will never be reimbursed.



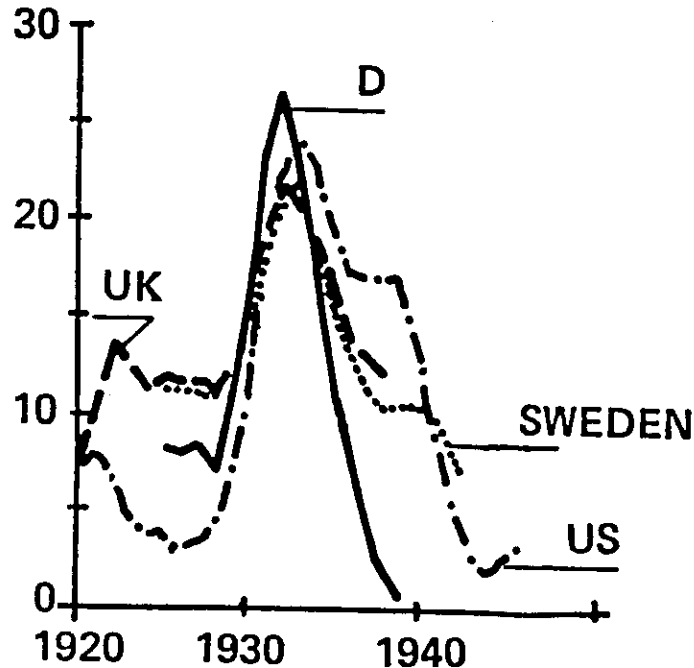
These two charts are dedicated to the believer in the thaumaturgic properties of interest rates and amortization rates as prime movers of the cycle. They report homicides (left) and suicides (right) on the second level. The first is the usual energy clock. If somehow out of phase, both cycles run on about 55 years to complete. The modulation is strong. Homicides at the top of the cycle are almost *double* than at the bottom. They are *rates*, i.e., expressed per 1,000 population. What is really striking, and an indicator of deep tides in mood, is the ratio of guns to knives in committing the homicides. The ratio oscillates with a period of 55 years. The modulation is very strong, about a factor of 3!!!. During recession one tends to stab. During boom, to shoot. Perhaps psychoanalysts could throw some light on Kondratiev cycles.



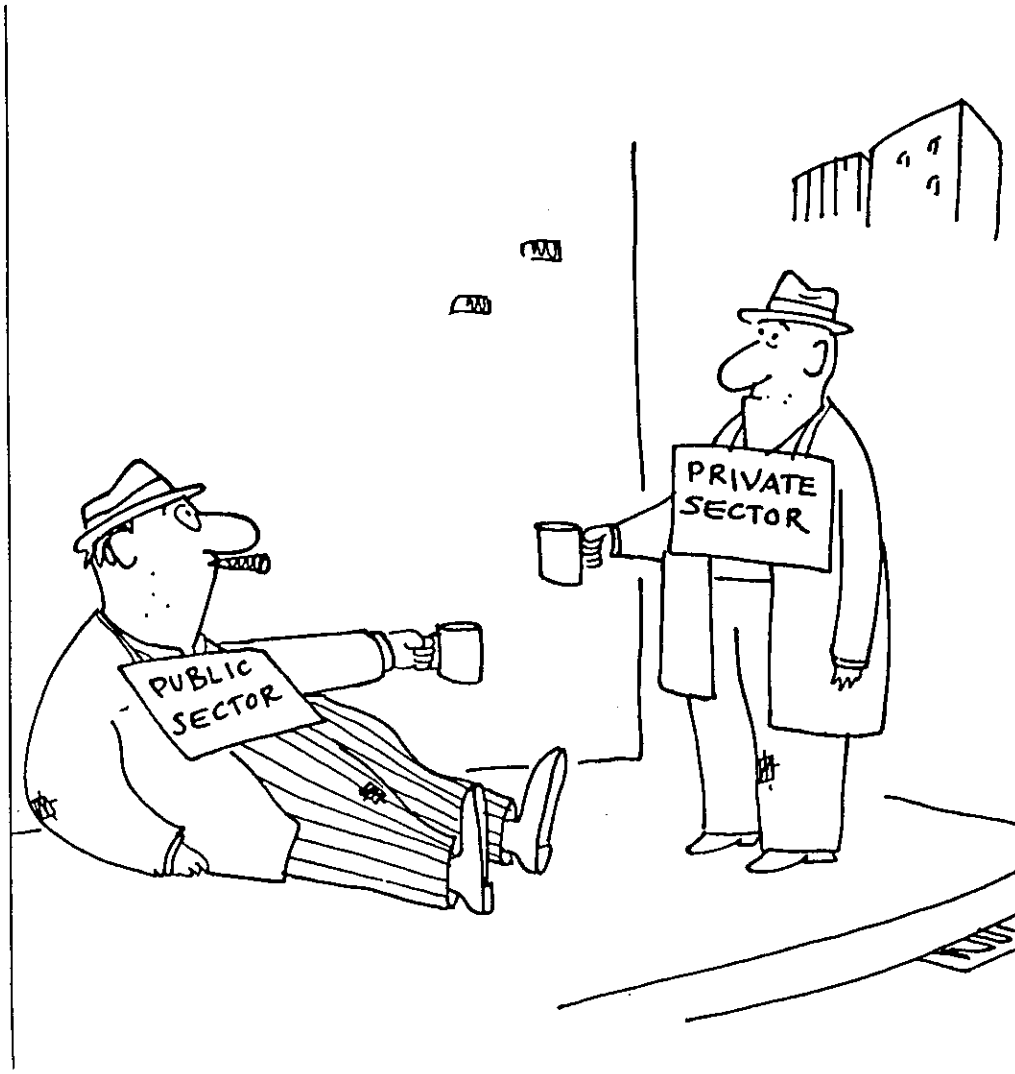
Data: US Historical Statistics & MVMA Statistics, 1987

As said in the text, money is there, the need also, but the greed is weak. This is clearly shown in the charts above, showing cars registration in US and Europe. A first (and fast) logistic saturates around 1940, the end of the previous Kondratiev cycle, with 26 million for US and 7.5 million for Europe. One may think that this is due to recession or war, but the logistics were well established already in 1930, and bound to saturate in 1940. One may think that the markets were intrinsically saturated but the following Kondratiev brought the members to about 150 million in both cases. Money was not the problem either, if one looks at the huge amounts that went into speculation (and, incidentally, Government Bonds!).

SYNCHRONIZATION OF 1930–1940 UNEMPLOYMENT



Unemployment is difficult to estimate in the agricultural economies of last century. So the only workable example comes from the last Kondratiev recession 1913–1940, which culminated in the breakdown depression of the 1930s. It is clear that four very differently organized economies, Germany, UK, Sweden, and the USA behave almost identically, both in timing and scale of unemployment. The effect must be deep and structural. It is highly probable then, that the *rain dances* of raising interest rates, lowering interest rates, changing tax incentives, etc., change really nothing. The *retreat of the buyers* cannot be influenced by a reduction of the Lombard by 0.3 points.



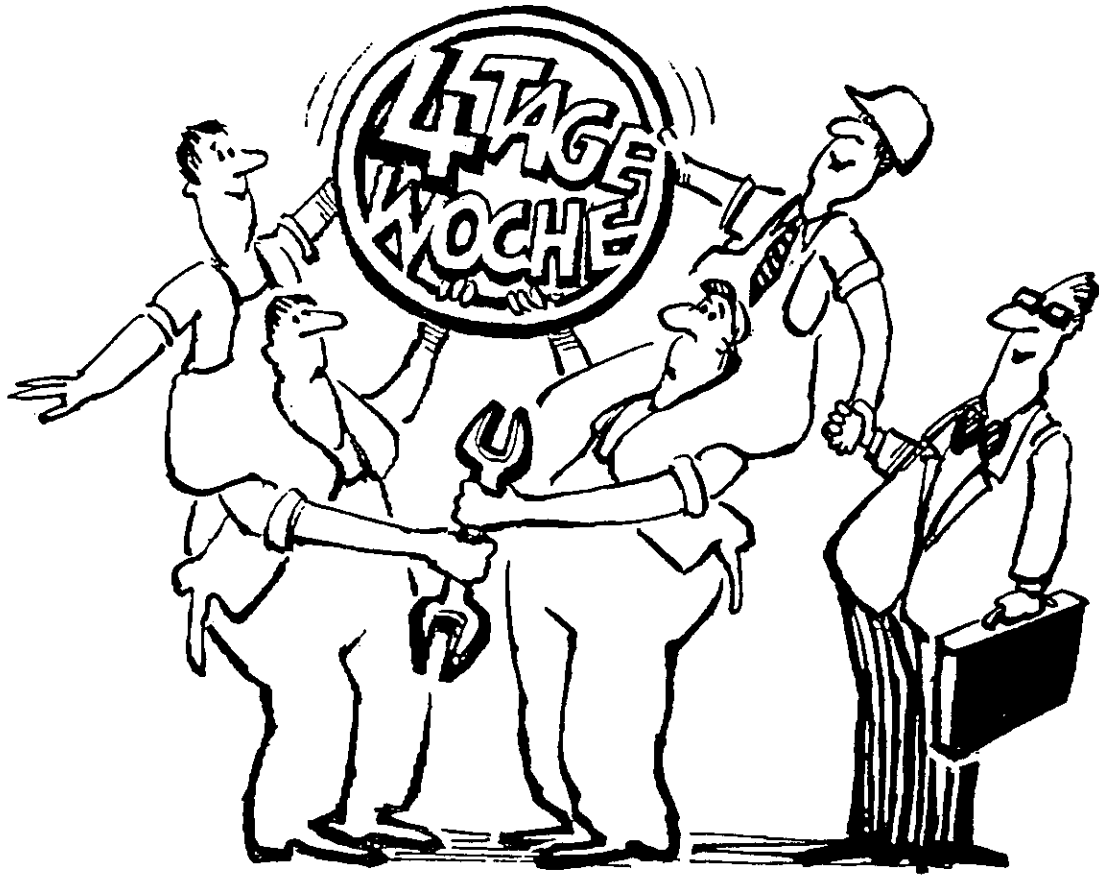
When the *Spielgeld* of the savers dries up the attitude of governments and private sector enters the doldrums. The private resents reduced “generosity” by the public hand and the public hand tries frantically to pick the last mark inventing new taxes aiming at reducing the tax burden, or making payments more agile (see Italy).



When the knots become inevitably tight, the next strategy is discussion. With all interested parts present. Obviously, nobody wants to give up. The years of boom have been usefully employed by the unions to brace workers' positions against any contrary economic force. The recession bird does not seem to be scared by words and resolutions. Nor the buyers come out of their meditations. Financial games seem to be the only lively pursuit. The adoration of the scriptures (financial) instead of the goods (golden calf) have curious biblic resonance.



One of the popular games, especially when elections approach, is to fiddle with numbers. For me, an unemployed person is one that would like to work (even if financially he does not necessary need it), but cannot find a job. Pre-pensioning is a nice way to make unemployed disappear. A few years later pension funds will bust. Keeping state employees busily producing nothing is another scheme, much welcomed in Italy (il *posto statale*).



A clever exercise in arithmetic consists in properly sharing working hours between existing workers. Assuming the real unemployed are 20% (as in 1933), this would mean taking away one day per week from present employed giving it to the unemployed. The employed refuse as this would mean a reduction in salary, although they collectively pay the same in taxes, to take care of the paid vacation of the unemployed. In the USA this wall has been partially broken by introducing extensively part-time jobs. The end of Kondratiev cycles tend to be revolutionary with crushing of old structures and the making of new ones. Free egoisms may well be finally crushed.