

# Is History Automatic and Are Wars a la Carte? The Perplexing Suggestions of a System Analysis of Historical Time Series

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## Resume

During the past 30 years, I have analyzed thousands of time series concerning all sorts of social and economic phenomena—from the destruction of the threshers (1 month) to the evolution of British naval power (500 years), from the rounds of artillery shot in Europe by American forces during WWI to American casualties in the Vietnam War, from the victims of the Red Brigades in Italy to those of the witch hunts in the Middle Ages, and so on. The perplexing result is that a very simple logistic model can always fit the data in a predictive format.

The usual enlightened belief that human events are the result of the fight between competing and collaborating free wills—in imprecise contexts, with unpredictable consequences—seems to be challenged by these results. History appears as the smooth deconvolution of a built-in program where free wills lock in to make it smooth. There appear to be many programs, in fact, like wheels within wheels, strictly clocked by ubiquitous Kondratiev cycles or waves, so that details are describable and predictable. This can be seen in *Figure 1*, where logistic center points of transportation infrastructures in the USA, subway starting dates for the world, and innovation waves are reported against the deviations from an exponential of energy consumption in the USA. It must be clear that I am not presenting a theory here, but rather some conclusions from numerous—that is, a few thousand—empirical analysis.

## Introduction

About 30 years ago, in an effort to solve the problem of the historical evolution of the energy markets, I came upon the idea that, the system being mostly “more of the same,” primary energies might compete much as species in a biological niche, a subject well modeled by mathematical biologists in the 1920s. The idea proved extremely fruitful in the area of energy, so much so that I progressively tried to extend it to other areas, with the above argument that the system appears to be mostly more of the same. This worked beyond my expectations: magically, data time series in the most variegated social and economic areas could be fitted with simple logistic equations, the most elementary solutions of the Volterra–Lotka equations of competition. The following pages will show a perhaps very interesting but inevitably limited sample mainly related to war; but if it whets the curiosity of the reader, he/she can browse my Web site ([www.cesaremarchetti.org/](http://www.cesaremarchetti.org/)), where most of the papers can be downloaded.

Man is a territorial animal, and most wars are squabbles over territory; it may therefore be instructive to dig deeper into the mechanisms of territoriality. There is a basic territorial instinct imprinted in the limbic brain—or our “snake brain,” as it is sometimes dubbed. This basic instinct is central to our daily life, and its deployment is analyzed in my 1994 paper “Anthropological Invariants in Travel Behavior.” Only external constraints can limit the greedy desire to bring *more territory* under control. The main constraint in daily life is *travel time*, fixed at *one hour per day* by another basic instinct (the one hour of open-air exercise time given to prisoners). Thus there is only one way to escape this constraint and expand territory, *speed*. The daily fight to conquer more territory with higher speeds has its own blood price: according to World Bank statistics, an estimated 1 million people die and about 20 million are injured in road accidents every year. Even before starting a war, we are soaked in blood.

A human can walk about 5 kilometers in one hour, and this was the basic unit for land organization before the advent of machines built for speed. In fact, all land has been always tiled in 5-kilometer parcels, 20 square kilometers of surface, often with a village in the center. The village could grow into a capital city of 1 million people, if it stayed within the 20-square-kilometer tile. Until 1800, no city grew in size beyond that extent. Seven tiles make up a hierarchical bundle of the first level, with a more important village in the center (weekly markets); and a bundle of seven of these makes the second hierarchical level, and so on, until we find a capital. Nations are always organized in this way. Now, however, the tiles are becoming larger, because motor vehicles permit greater speeds. Since Ford, cars have had a mean speed of about 40 kilometers per hour, allowing the area of the tile to become about 50 times larger. The largest cities can then grow even larger; imperial Rome had 1 million inhabitants living within 20 square kilometers, and a “car city” like Mexico City grows according to a logistic equation, becoming saturated at 50 million people, but with the same population density as ancient Rome. The snake brain organizes space from the bottom to the top, even if our rational conscious is not much aware of it; and in spite of this, historians try rational interpretations.

The territorial instinct also operates in the heads of the rulers of a state, who visualize a nation as an extension of their limbs (*l'état c'est moi*) and try to expand it with a panoply of rationalizations. It would be interesting to make a catalogue of these rationalizations for psychoanalysis. In reality, the drive and objective are the same for a nation as for the individual: more land under one's control, thus, more power at hand. If a nation is vigorous and the boundary conditions are appropriate, the territorial expansion will produce an

empire. I have analyzed a number of examples from history. They grow logistically with time constants of hundreds of years, following one single equation. Logistics saturate, so they have a limited size. I discovered that this corresponds to a couple of weeks of travel from the capital to the rim using the fastest transportation system available. Emperors build roads for a good reason. There must be an anthropological explanation. It is given in the above paper: submission to the chief must be refreshed at least once every moon cycle to make it last.

So we have anthropological machinery, basically subconscious, that organizes territory, leads to empires, and presumably inspires wars. Speed, as said before, is the key to larger territories, and the use of the airplane permits a global empire, because any place can be reached in less than two weeks. The idea has been caught by multinationals that by all means have become global. And, incidentally, once a month they have their top managers meet somewhere to refresh the hierarchy, although the formal motives are to coordinate business and exchange experiences. The political machinery is much more viscous, and we may have to wait at least a century to see a global empire, but very interesting agglomerations like the European Union are already coagulating. However, the only real way to control multinationals is to go global. One of my whimsical hunches is that the Holy Roman Empire was an invention of a fragmented political system organized to control a multinational Catholic Church. As Voltaire said, the HRE was not holy nor Roman nor an empire. (See my paper: "From the Primeval Soup to World Government: An Essay in Comparative Evolution," 1976)

Incidentally, the fact that the growth of an empire follows a single logistic equation for hundreds of years suggests that the whole process is under the control of automatic mechanisms, much more than the whims of Napoleon or Genghis Khan. Some years ago, I stumbled across a very interesting set of statistics produced by George Modelski on the evolution of Britain's naval power since the end of 1400. He meticulously reconstructed, for 500 years, the number of men-o-war in operation at any time. I was able to fit their cumulative costs to a set of seven logistic equations. (See "Looking Forward, Looking Backward," a 1996 paper I wrote to tease historians at a conference in Urbino.) Modelski observed that the dates of the center points of these equations did in fact correspond to big naval battles. My cynical interpretation is that one fights a battle when there is somebody around who is sufficiently weaker—as in pubs. This is my *pub theory of history*.

In a more academic format, I could say that the anthropology of behavior leads to basic instincts as prime movers, and that individuals and organizations have the same kinds of equations pointing to the same basic mechanisms. The intuitions of Menenius Agrippa in ancient Rome and of Renaissance Hobbes in his *Leviathan* may, after all, be scientifically true. In the same spirit, biologists are discovering that most of the machinery to build a human was already inside flatworms. I tried to synthesize this evolutionary consistency in my 1996 paper "On the Limits to Knowledge."

I also observed that the group of British Navy equations have a long-term internal logic. If one takes their center-point dates and puts on them their saturation value—that is, the total expenditures in that wave—one obtains a set of seven points sufficient to draw a logistic, if the noise is not too high. This superlogistic comes out very nicely and without noise. It saturates in the middle of 1900, in curious correspondence with the loss of naval supremacy by the British Navy. Furthermore these centers are separated, if somewhat irregularly, by a mean distance of 55 years. Kondratiev again? So, following the Modelski observation, big naval battles were spaced apart by about one Kondratiev wave. To time the K-waves, I use

the deviations from the exponential of US energy growth, total and electric, as in *Figure 1*. In this frame, 1914 is the center (top) of a wave and the next center is 1969. They sound like hectic years. The end of the wave centered in 1914 was 1940, but from a study I made (not published), WWII was the second serving of WWI, a sort of Thirty Years' War with a long truce. The year 1969 did not see a war between core nations, presumably because nuclear armaments were strongly dissuasive. However, the Cold War was waged indirectly and, according to some sources, produced tens of millions of deaths, a good proxy for war. The USA ultimately won the cup. The previous K-wave centers were in 1859, when central Europe entered a period of turmoil, and 1804, the core of Napoleon's enterprises. Before that, the wave center was 1750.

I have a hunch about why wars tend to cluster around the centers of the K-waves. The first part of the cycle represents a period of boom and growth. However, nations grow at different speeds, so that after 30 years the cards are mixed in the sense that the relative powers change. In my cynical pub theory of history, this tempts the newly stronger nation to punch the newly weaker one. As with social animals, nations have a hierarchical order. America is Number One, having inherited that position from Britain. Looking at Number Ones at a glance, one sees that they tend to last one Kondratiev cycle, more or less; Britain lasted for two. Being Number One fills the nation's hearts with pride, but is extremely expensive, so Number One tends to go bankrupt. When Britain threw in the towel, its debt was about three times its gross national product. When a Number One quits, the next ones in rank fight a core war to pick up the cup. Bloodshed is immaterial. *Becoming Number One is another basic instinct* from the snake brain.

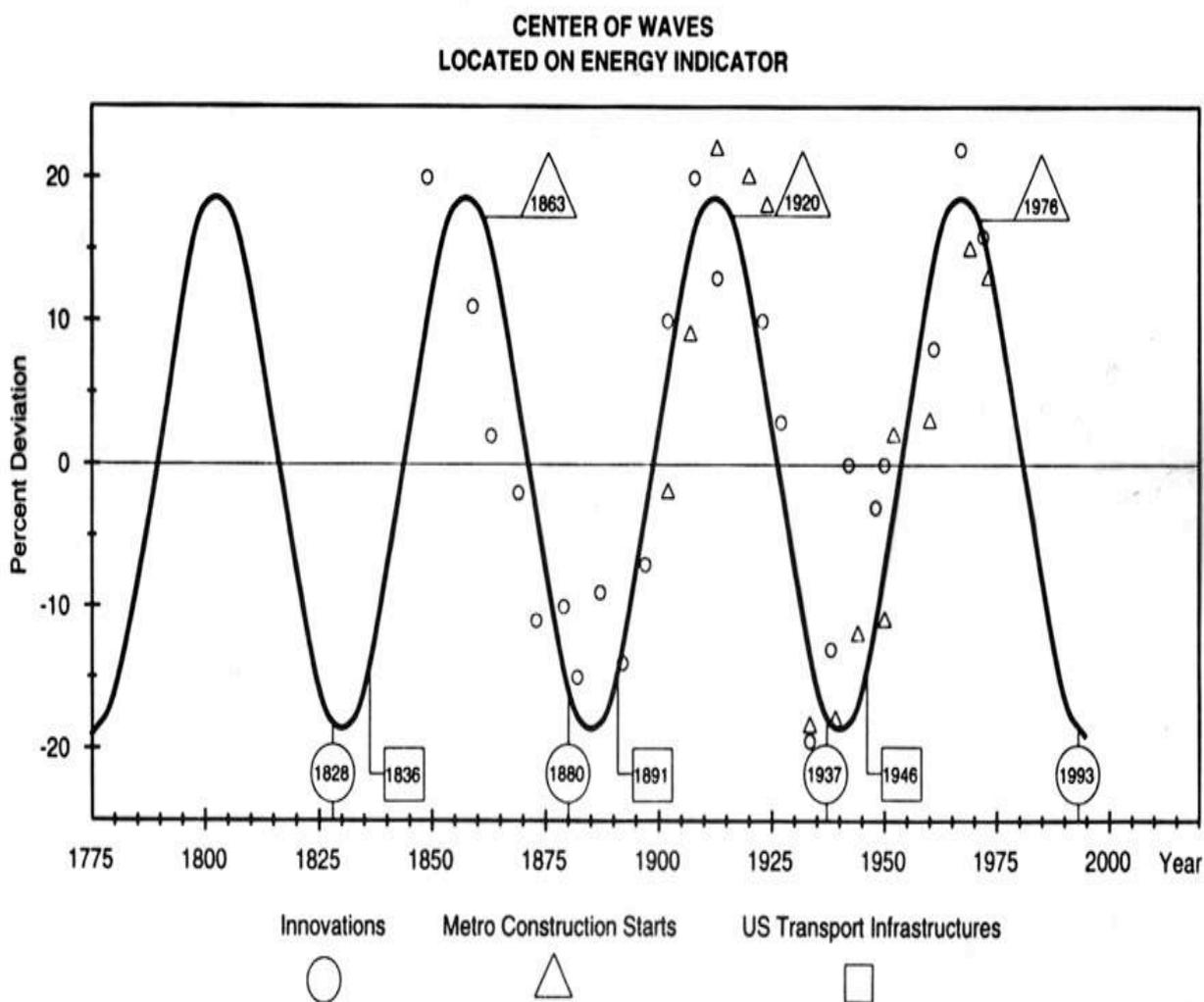
Real historians at this conference have certainly filled in all the gaps and innuendos of my presentation, so, the time constraints being very narrow, I had better shift to subjects they will most probably not present, but that are connected to the title of my discussion. One of the reactions I often get when I present my analysis of big events, pointing out the fact that they have an internal, long-term order that allows them to be described with simple equations, is that this is the effect of their being made of many parts and that the order is a consequence of complexity. So I analyzed the behavior of smaller and smaller systems, down to individual people (see my 2002 paper "Productivity vs. Age"), only to see that the same rules always hold. I do not plan to kill the holy cow of free will—I would hate to be lynched—but I must say it really looks like having more constraints than degrees of freedom. As historian Lynn White wryly commented, even the Church always avoided taking a definite position.

At this point I suggest that you download my 1992 paper "A Simple Mathematical Model of War Events," where I explain the mathematical methodology and analyze time series related to WWI, WWII, and the Vietnam War: strengths of armies, casualties, rounds of artillery, and number of planes in service. All can be fitted with simple and predictive equations. Fitting the facts with simple equations means that the facts have a *precise temporal order*, in processes that war correspondents and historians consider extremely confused and naturally stochastic. I think that even a single battle—for example, between two armies with large numbers of tanks, as happened in the Battle of Kursk during WWII—can be modeled and predicted on line, so to speak, providing an early warning for the side that will finally lose and permitting an early retreat to save lives and material. At present, this decision is left to the intuition of the commanders, always reluctant to admit defeat, and consequently it comes too late. I did not find the time series of the Battle of Kursk—that is, the number of tanks surviving at any time—but I will try the analysis

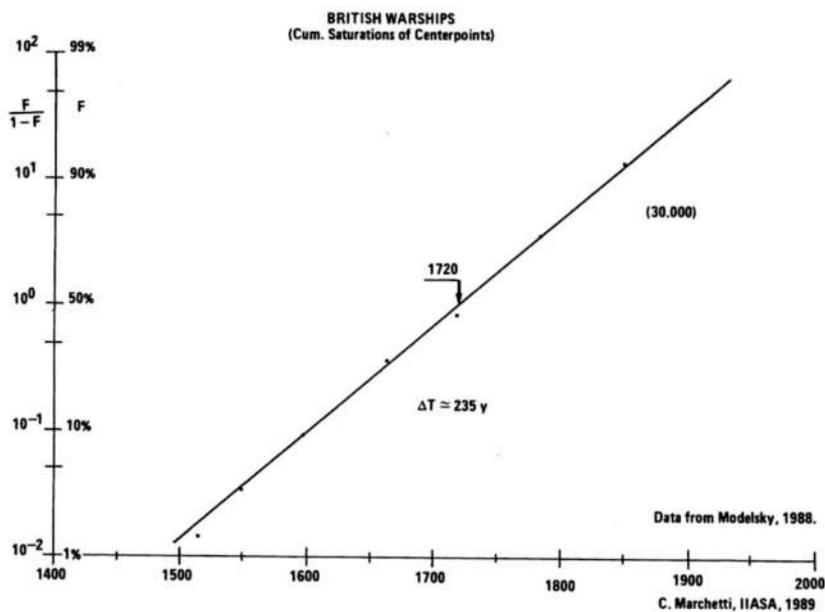
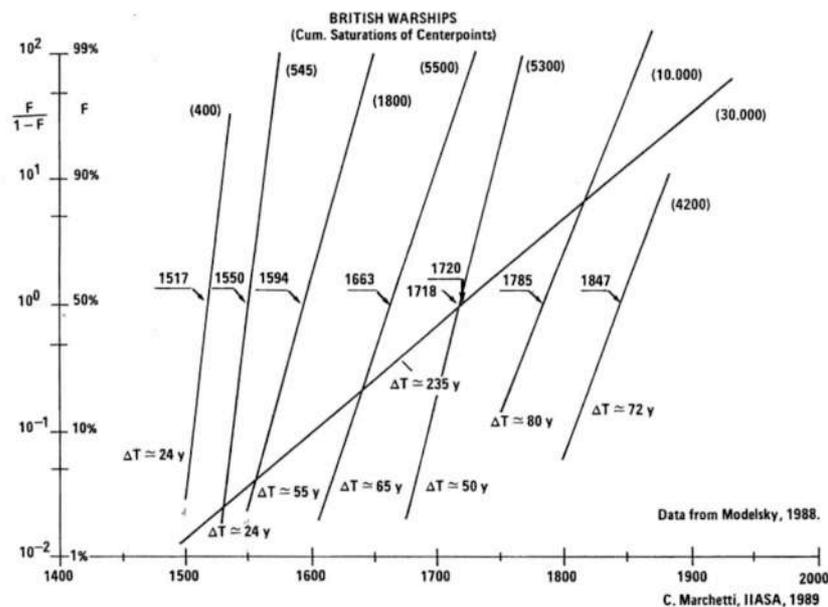
should they be provided. If it works, this could be an important tactical tool to run a war at minimum cost.

I have done various analyses on more or less recent armaments, their timing, and expenditures, always finding the all-weather logistics fitting the data. One case is reported in Figure 3, dealing with space expenditures in the USA and USSR during the sensitive years of the Cold War. The central point of the K-wave, where core wars tend to cluster, is 1968. The central points of the expenditures for the first space rush are in 1966 for the USA and in 1968 for the USSR. K-waves seem to be good timers. However, I have no idea about the meaning of the second rush for both countries 20 years later!

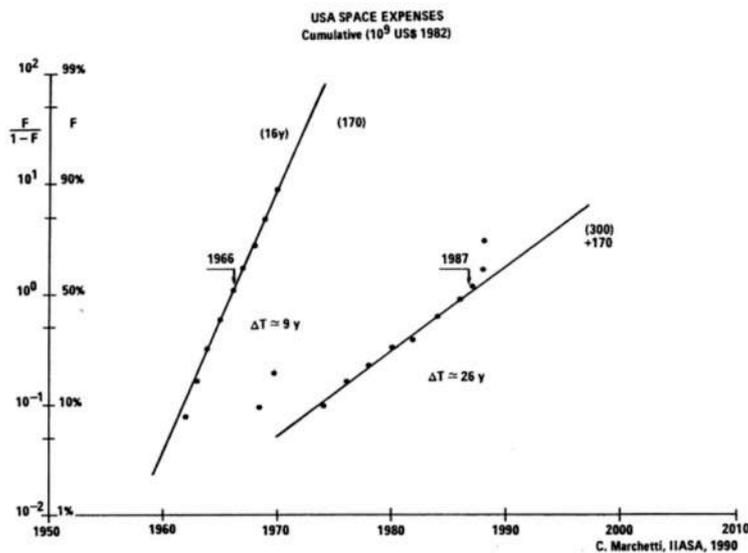
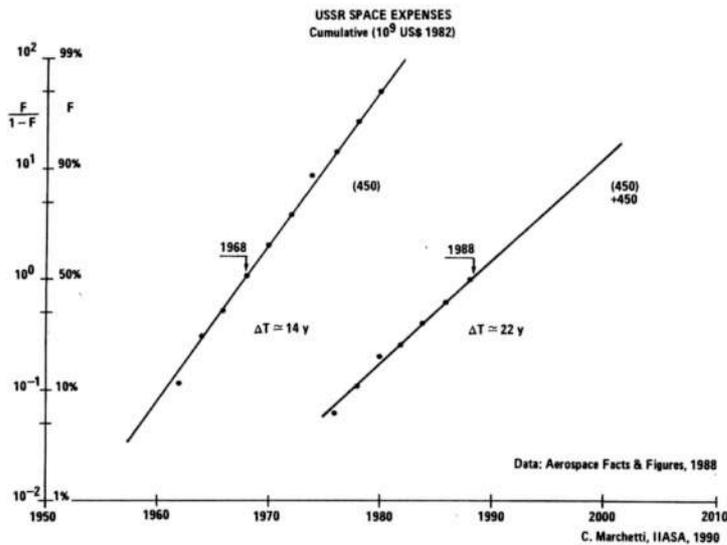
Terrorism is a form of war escaping the definition of contraposed armies, but faithful to the principle of damaging and disrupting an enemy system. Terrorism has been very active in the past 30 years, but I suppose it has always existed in some form. I have analyzed a number of sets of terrorist attacks, for example, the Red Brigades in Italy, the set of attacks on embassies, the attacks against Israel up to 1985, the international air terrorism centered in 1985, and other cases. The result of this exploration is that terrorism, as other things, has an internal logic, so to speak, and comes in waves and denominations that can be organized through the usual logistics. Most of the cases I analyzed happened after 1968—the middle Kondratiev wave—and I have the feeling that terrorism is typical of the second part of the Kondratiev, that is, the recession years. The point is that I did not find supportive statistics ranging over 100 years or so, in which case I could have analyzed the links with the cycle. These connections almost certainly exist: an analysis of homicides and the means of committing them in the USA for the past 100 years showed a neat link with the Kondratiev cycle. Just for the record, in the case of the Red Brigades, I was collaborating with the Carabinieri predicting fairly precisely a few years ahead the number of people that would be killed. They didn't like that.



**Figure 1.** This chart gives an impressive view of the power of the Kondratiev cycles to organize the system. The sinusoid comes as the residual of an exponential fit of the growth of US energy consumption, both total (circles) and electric (triangles). It is extracted from the tides of the US economy, but it holds for the world as well. Innovations come in logistic waves, as described in my 1980 paper "Society as a Learning System." The metro construction starts are again a set of three logistics that organize the dates of the opening of the first line of the Metro in world cities. US transport infrastructure takes the center points of the logistic growth in the length of canals, railways, and paved roads. All these center points have the *same phase position* on the different waves over a period of 200 years.



**Figure 2. British naval power.** For those who enjoy a deep breath into history, this is a chart to ponder. Modelsky painstakingly collected the data on the force of the British Navy, in terms of number of operational warships since 1470. I thought the expense of maintaining this navy, measured in warship-years and *cumulated*, could give a measure of the aggressive *elan* of Britain. Actually, after much labor, I was able to splice this sum onto a set of logistics, seven of them, pretty well delineated, and with center points that Modelsky himself has found historically very significant because they correspond to big naval battles. So the big naval battles are embedded in long-range processes starting long before and fading out long after them. The distance between these action pulses is irregular, but with a mean of about 55 years, reminiscent of our Kondratiev cycles or waves. To take a breathtaking look at the secular evolution of British sea power (400 years!), I used the trick of concentrating the total intensity of a pulse (integrated warship-years) on the point of that pulse. Using the dates and the values so obtained, I constructed a superlogistic, centered in 1720 and *ending* around 1950, in tune with the loss of British naval dominance. The end in 1950 could have been predicted with fair precision 100 years before.



**Figure 3. Space expenditures for the USSR and USA.** During the various phases of the post-WWII period and the Cold War, space expenditures were considered a sensitive indicator of the actual moods and intentions of the antagonists. My personal impression, formed for the most part from accounts in the press, was that one considered the decisions about space expenditures as something that had to be pondered *year by year* in order to match, to menace, or to impress the counterpart. If this is true, then it may come as a surprise that, for both the USSR and the USA, these programs developed according to a rigorous, *long-term*, internal logic. This might mean that real decisions were taken in the subliminal instincts of both systems, operating according to the same rules, at least in this respect. For the USA, the first wave of expenditures was centered in 1966 and a flash of activity with only 7 years of time constant. For the USSR, the center point was 1968, very near if slightly later than in the USA, and a more leisure time constant of 14 years. The total expenditures were much larger, by a factor of three, although the purchasing power of the ruble was difficult to assess. The second wave for the USA is centered in 1987, with a time constant of 26 years; that for the USSR is centered in 1988, with a time constant of 22 years. So the second pulses were very similar in shape, but the Russians again spent about 50% more. The two pulses may be justified or explained on various grounds. I obtained them in a very formal way, by discovering that the data for both the USA and the USSR could be fitted by the sum of two simple logistics. This “splicing” can be done in only one way.