Economy and Energy - NGO

Nº 45

August - September 2004

http://ecen.com

Economy and Energy

Periodical

Rio: Av. Rio Branco, 123 Sala 1308 Centro
20040-005 Rio de Janeiro RJ Brazil
Phone: (55-21) 2222-4816
BH: Rua Jornalista Jair Silva, 180 Bairro Anchieta
30310-290 Belo Horizonte MG Brazil
Phone/Fax (55-31) 3284-3416
Internet :http://ecen.com

Graphic Edition: Marcos Alvim

Economy and Energy – http://ecen.com

No 45: August-September 2004
ISSN 1518-2932
Also at Internet: http://ecen.com

Article:

The main objective of science is the elaboration of models that are capable of describing the outside world. Consequently, the touchstone of scientific models is their capacity to forecast events. Science should also be amenable to examination rooted in the same concepts. Based on a lecture given at the former Secretariat of Strategic Studies of the Presidency of the Republic, the text presents an instigating prediction model – applied and applicable to various systems – where the past strongly guides the future.

Text for Discussion:

In previous articles, the capital productivity decrease has been pointed out as the largest hindrance to economical growth. In the present article some macroeconomic and microeconomic measures are suggested aiming at increasing the capital productivity.

THE TECHNOLOGICAL PROSPECTIVE: PREDICTION WITH A SIMPLE MATHEMATICAL MODELING [1]

José Israel Vargas(*)
jivargas@abc.org.br

"L'homme est ce qu'il fait"- André Malraux in Les Noyers de l'Altenburg

The Author

I have been invited to summarize in a few lines the whole experience of a long life; I have clearly chosen to enumerate the facts, the people and the places that in some way have influenced the path of my existence.

I got a Bachelor of Chemistry degree from the Federal University of Minas Gerais (UFMG) in 1952, combined with a period at the São Paulo University, where I became particularly attached to Physics. Invited by Paulus Aulus Pompéia e Abraão de Morais, I was engaged at the Physics Department of the Aeronautics Institute of Technology, where I remained for two years. A course offered in Chile and organized by the Cambridge University gave me the possibility of getting a PhD degree in Nuclear Science from that old institution in 1959, on the physico-chemical consequences of nuclear transformations in solids. The determination of the state of the atoms that have undergone such transformations required the use of different physical methods that involved measurements of hyperfine interactions: perturbed angular correlation, Mossbauer effect, half-life variation and the use of correlated techniques such as nuclear magnetic resonance and paramagnetic electronic resonance in the matrixes under examination. These studies were developed later on, during a six years stay in Grenoble, under the stimulating and friendly influence of Louis Néel, Pierre Baligand Daniel Dautreppe and André Moussa. Discussions with Louis Néel concerning the results obtained led to examine the possibility of demand for patents. The permanence in Grenoble was preceded by a return to UFMG (Federal University of Minas Gerais) and to the old Institute of Radioactive Research, where the research started in Cambridge was carried on. At that time I became Full Professor of Physical-Chemistry and Advanced Chemistry and supervised several PhD and MSc dissertations. These activities were followed by my choice as director of the UFMG's Institute of Radioactivity Research. On my return to Brazil and to the University, an invitation by Aureliano Chaves, newly elected Governor of Minas Gerais, to organize the first Secretary for Science and Technology of Brazil that, incidentally, was also a pioneer in the tackling of environmental problems. At the end of his administration, this politician, an ex Electrical Engineering professor and close friend, becoming Vice-President of the Republic and João Camilo Penna, the new Minister of

[1] This article resulted, in part, from a previous extensive research study carried out within the ambit of UNESCO's Participation Program Nº 5136 (1990/91).

Industry and Commerce have both led me to direct the Secretary of Industrial Technology at that Ministry. Elected member of the Brazilian Academy of Science in 1975, I developed close friendships with my new colleges, particularly with President Aristides Pacheco Leão (who later on was to be nominated as its President Emeritus), and with his successor, Maurício Peixoto, in whose term I served as Vice-President for eleven years. Elected for two terms to UNESCO's Executive Board (1981-1989), I was chosen to discharge of various functions - as Vice-President and finally as President in the 1987-1989 biennium. These diversified scientific, academic and diplomatic activities might have induced Presidents Itamar Franco and Fernando Henrique Cardoso to invite me to serve as Minister for Science and Technology - a position I held for six and a half years. The latter President appointed me Ambassador and Permanent Delegate at UNESCO for Brazil (2000 - 2003), and later on as his Special Adviser during two years, to organize the Inter-ministerial Commission on Global Climate Changes. I recall as particularly significant my obligation as Chairman of the Presidential Commission for the Revision of the Brazilian Nuclear Program (that later led to the establishment of mutual nuclear activities inspections between Brazil and Argentina); the participation in the Committee for the rebirth of the Alexandria Library; as head of four conferences of Parties devoted to the implementation of the Eco-92 Conventions, which have finally led to the formulation of the so-called Kyoto Protocol. I am of course proud of the success attained by my countless students and collaborators spread throughout many places; having succeeded Abdus Salan as President of the Third World Academy of Sciences (that counts among its members the most prominent scientists from about fifty countries) was a great honor. It has offered me the unique opportunity to contribute to the development of Science in the poorer parts of the world, particularly to Africa. Finally having been for several years a member of the Board of Directors of the Lampadia Foundation, I had the chance to participate through its different branches Andes, in Chile, Antorchas, in Argentina, and Vitae, in Brazil, in many assistance projects devoted to the development of education, science and culture in these countries. Here again I had the chance to make several new, distinguished and very dear friends. Presently I represent Brazil as Vice-President at UNESCO's Executive Board for another term on behalf of Brazil. At the same time I am also serving as a member of the Board of the Institute of Advanced Studies of the United Nations University (Tokyo) and also in the Board of the National Institute for the Applications of Nuclear Energy to the Environment – ICENS (Jamaica). I have actually returned to the modeling exercises on social-economic and scientific-technological systems with which I have been previously occupied – in the eighties - under the influence of the studies carried out by C. Marchetti and his group at the International Institute for Applied System Analysis of Laxemburg, Austria. My initial studies on these topics have been carried out particularly at CBPF (Brazilian Center for Research in Physics) and at the Brazilian Academy of Sciences in the eighties, at that occasion with the support of UNESCO.

Preliminary considerations

Let me recall that Cesare Marchetti whom I had the honor to meet a number of times, years ago, told me that the model which I shall be presenting to you this afternoon occurred to him as a result of his deep conviction that whenever an explanation is thought for a complex process, one should first ask how life faced analogous situations. He argues that after all, according to modern biology interpretation of evolution, countless experiments by DNA have generated and launched into the environment a vast variety of living organisms competing among themselves for food gathering and consumption along the last three billion years – evolution consisting of mutation, selection of the fittest for survival and multiplication to finally diffuse into the whole planet. This development has crystallized strict behavioral laws controlling the actions of all species, including those of the human beings themselves – both material and cultural.

Having been asked to examine whether it would have been possible to predict the 1973 oil crisis, that so dramatically affected world economy, Marchetti and coworkers resorted basically to the models of ecological competition first developed by Volterra in his famous "La theorie mathématique de la lute pour la vie"(1) , Lotka (2) and Verhulst (3), who formulated in mathematical language the Darwinian theory of evolution of species).

Marchetti therefore considered different primary energies to behave in the global market as living species competing in a niche according to mathematical presentation formulated by the above mentioned authors, and later reviewed by Montrol (4). The original treatment of the simplest case of competition between two species, the only that actually allowed for an analytical solution, was extended to cover a larger number of competitors by a numerical approach.(5)[2] The almost perfect agreement obtained between theory and (accumulated) observations on the "energy system" behavior led Marchetti to wider and innovative applications of the model.

Firstly he concluded that total worldwide primary energies growths, particularly in the U.S – due to abundance and reliability of data concerning that country - obeyed the so called logistical equation, a particular solution of Volterra`s differential equation. Secondly, in a very daring inspiration he stressed that close connection existed between the

[2] Recent rigorous analytical treatment for three competitors has been presented: A. Goriely and L.Brenig, Physics Letters A 1990, 145-5, 245; ibid, Physical Review A, 1989, 40-7, 4119; L. Brenig, Physics Letters A, 1988, 133-7,8, 378.

primary energy time evolution behavior and the evolution of inventions and innovations which were independently described in a study by Mensch (6) (covering about two hundred years of history). In fact, both sequences oscillate with a 55 years periodicity. The periodicity for the primary energy system evolution had also been previously noted by Fish and Pry (7). The close correlation between inventions and innovations with new energy technologies – considered as driving forces of the world economy fluctuations - had also been previously scrutinized by Schumpeter (8). Finally, the bridge between the capacity of doing work (which is the most elementary definition of energy) and the purely intellectual exertions involved in the inventions and innovations as well as the most diverse social actions led the Italian researcher to successfully extend his model to about 3,000 applications covering increasingly more abstract activities.

Introduction

The Lecture, presented by the author at the Brazilian Federal Government Special Secretary for Strategic Policies in April 1995, displayed a large number of graphs due to Marchetti on the subject and contained in articles listed in Annex 1, as well as a certain number of figures that summarized applications of the model to some Brazilian situations (9, 10). The absence of detailed explanations for the results contained in the figures arose from the expectation that queries from the audience would offer the opportunity for additional comments. As a result of the short time made available for the preparation of the Lecture, its transcription for publication contained a number of errors, in the illustration captions (presented in the English and often in Portuguese), in the text, and even in the presentation of one mathematical equation. The original Portuguese version (without the corresponding illustrations) was made available on the internet (without the knowledge of this author), possibly due to the electronic diffusion of the “Parcerias Estrategica” periodical where the text was first published. These facts have led the author to prepare this final text, hopefully without the aforementioned mistakes. I thank the kind cooperation of Frida Eidelman and Carlos Feu Alvim for the cooperation in the present revision

The problem

The main objective of science is the elaboration of models that are capable of describing the outside world. To this aim, it resorts mainly to the classical concepts of determinism and of causality, the core of the classical description of the world (11,12). Consequently, the touchstone of scientific models is their capacity to forecast events. Since science itself is part of the outside world – a human creation – it should also be amenable to examination rooted in the same concepts, that is, by the scientific method. Nevertheless, it should be noted that scientists have seldom tried to model science adopting their own methodology to search the laws connecting variables that presumably might reveal the evolution of the number of scientific and technological findings. These indicators should always be quantifiable so as to allow for the forecasting.

This circumstance is probably due to the fact that science, itself admittedly being a social activity – a part of human culture and should therefore also be open to reflections – that is carried out almost only by philosophers and social scientists. While they are perfectly capable of handling mostly verbal concepts, they are, in fact, frequently incapable of dealing with the mathematical techniques required for more quantitative modeling exercises. But, as it is known since Pythagoras and explicated by Galileo, the Book of Nature (which includes also human actions) is written in numbers... So, in order to interpret the observed actions, it is indeed necessary to resort to the powerful and flexible language of mathematics. Only its utilization permits the identification of regularities that might illuminate many aspects of social life, including those pertaining to science and technology. That is the objective of the present lecture. In fact, we intend to show that their (science and technology's) activities may thus be examined, thanks to the application of the model utilized in the large variety of papers listed in Annex 1 and more particularly in reference (12).

According to this model, human endeavors result from the adoption of paradigms of actions[3] (decisions to act) compounding a deep urge within the social systems themselves. New ideas, concepts, products, inventions and innovations come forth in new formats different from what existed previously – in response to existing needs or as an innovation presenting a better performance. Thus, ideas, new objects or mechanisms, services – including those of a purely intellectual character –are invented, or created via the mutation and selection so they can be dealt with by the model that we now describe. Such actions can be represented by well chosen numerical indicators.

According to researchers from the University of Lund (13), Sweden, the acceptance of these "mutant" innovations implies the action of a small, organized group (a cell) of individuals that initially exchange oral information on the subject (ideas about innovative actions) under their consideration. For these researchers, each one of these cells should

[3] Action decisions, carried out along time, cumulatively expressed by appropriate quantitative indicators.

contain at least a hundred individuals allowing for the innovation to spread efficiently. After due filtering through competition, the innovation is thus eventually accepted by society (market, community, etc…). Therefore, competition between "mutants" is the filter.

In the case of technology, the market demands it be acceptable and reliable. For its acceptance to occur, it should be launched at the right moment (for reasons to be made clear later on...). It will be reliable if it resists the relevant market competition tests; finally it must doubtless be more acceptable than the one "species" it replaces.

Price is probably the least important point of concern, since it will have only a small consequence on the market acceptance of the particular innovation. Let us recall that innovation – ideas, concepts, mechanisms, services - technology included, must be more efficient than the ideas, concepts, mechanisms, services or technology it is to replace. Admittedly, it is difficult to measure the efficiency of an idea or of a concept, despite some glaring and well-known exceptions. In living nature, as well as in many man-made systems, such as those involving technology competing alternatives, a 1% efficiency gap between species and techniques in competition may be enough for a given variety (or species) to gradually occupy an ecological or market niche, leading sometimes to the virtual elimination – in due time, or to the reduction of market share of lower efficiency species or enterprises.

The action paradigm, as applied to this sector, means that after a competitive selection, objects and new ideas force themselves upon people, as imposing novelties, characterized by objects and concepts that are seen as so essential, that life is thought to be unbearable in their (unimaginable) absence.

The logistic equation

To describe the quantitative content to these ideas and following Marchetti once more, let us take as an example the London Plague of 1666 (12). Once the action indicators (number of events along time) are correctly chosen, the formal description is identical for every action paradigm referring to competing systems, involving a single species or the same class of diffusing event. Thus, the number of dead people in the London plague, per unit time is the chosen indicator. This number must be proportional to:

i) the number N of people already dead after being infected, i.e. the larger the number of those infected the greater the probability of others being infected.

ii) the number of individuals that remain to dye (N*-N), where N* is the totality of the population susceptible to the infection and to death. Analytically, we will have:

$$dN = a\,N\,(N^*-N)\,dt \qquad (1)$$

This is a non linear differential equation, which, when solved for N (t) (number of deaths at time t) gives:

$$N = N^*/[1-\exp-(at+b)] \qquad (2)$$

where **a** is a constant of proportionality, which determines the speed of propagation of the plague and **b** is the integration constant.

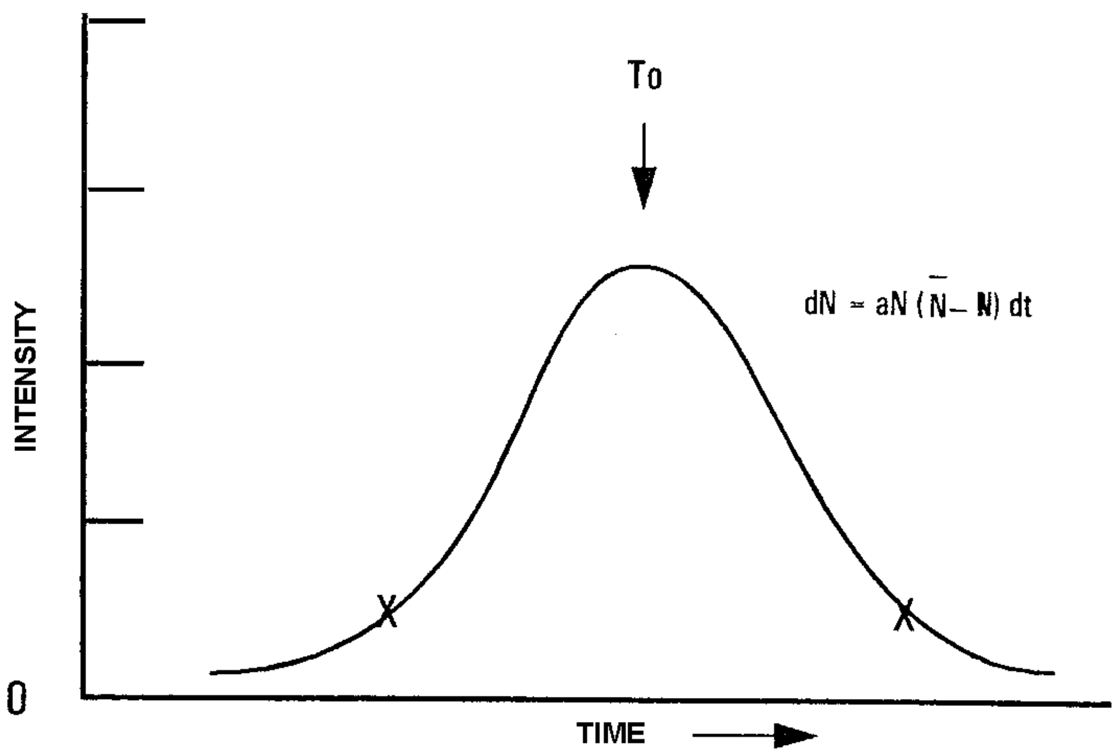


Figure 1

The first equation can be represented graphically by a bell shaped curve, as shown in Figure 1. At the beginning of the epidemics, N is small and therefore dN/dt is small, because N(N*-N) is small, and N is practically constant. As time passes, dN/dt eventually reaches a maximum when N = 0.5 N*, and half the susceptible population has been killed. After this time, N (N* - N) decreases, the number of deaths tending to zero. Equation (2) is the so called logistic or epidemiological equation, obtained by the integration of (1). It displays the usual S shaped curve, well known to epidemiologists and demographers. It is shown in Figure 2. If we adopt a relative representation for this equation, taking F = N/ N* (F is the occupation fraction of niche N*), after some simple manipulations, it becomes:

$$F/1-F = \exp -(at + b) \qquad (3)$$

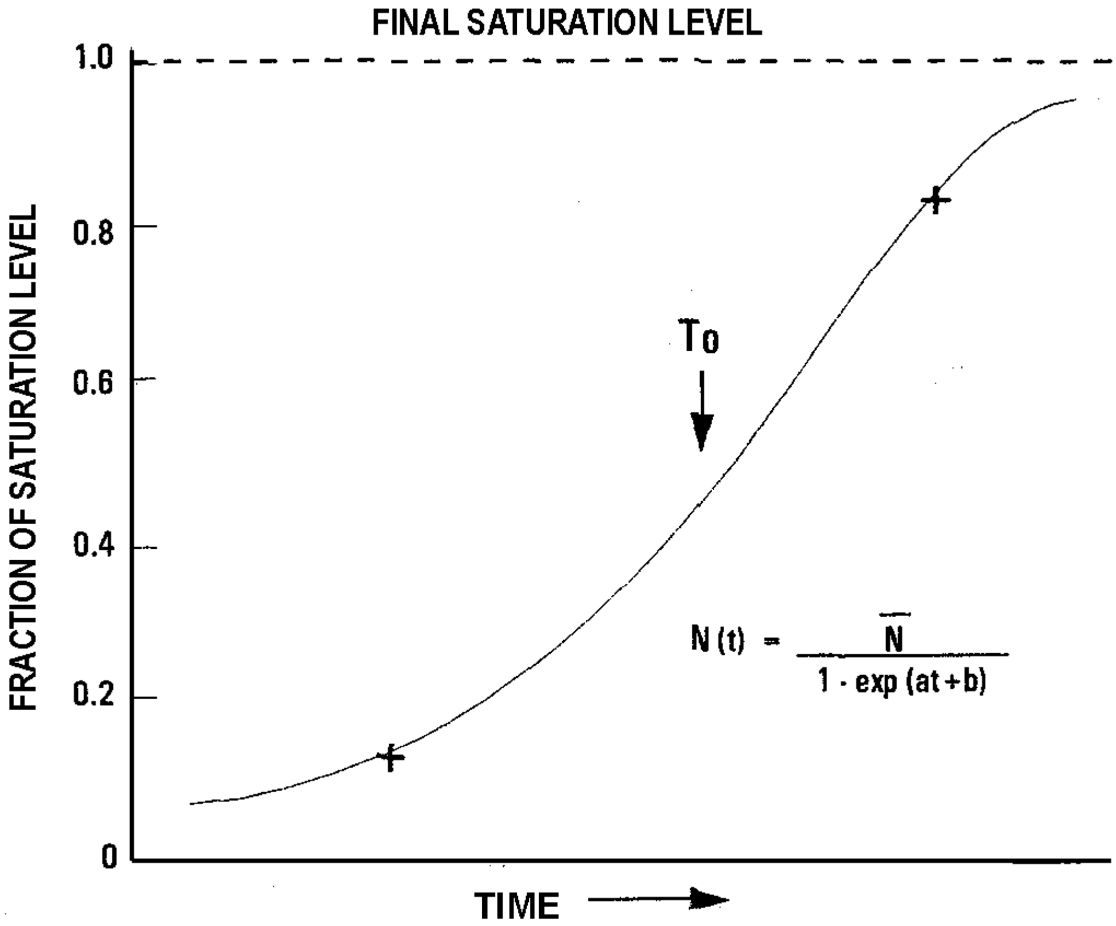


Figure 2

which may take the linear format (the so called Fisher-Pry presentation) which results from taking the logarithm of both sides of equation (3),as indicated below

$$\log (F/1-F) = at + b \qquad (4)$$

and illustrated in Figure 3.

A time interval ΔT is defined as the time taken by the process to go from F≈ 0.1 to F≈ 0.9 (from 10 to 90%). It represents 80% of the total process; the relation between ΔT and **a** is $\Delta T = 4.39/a$.

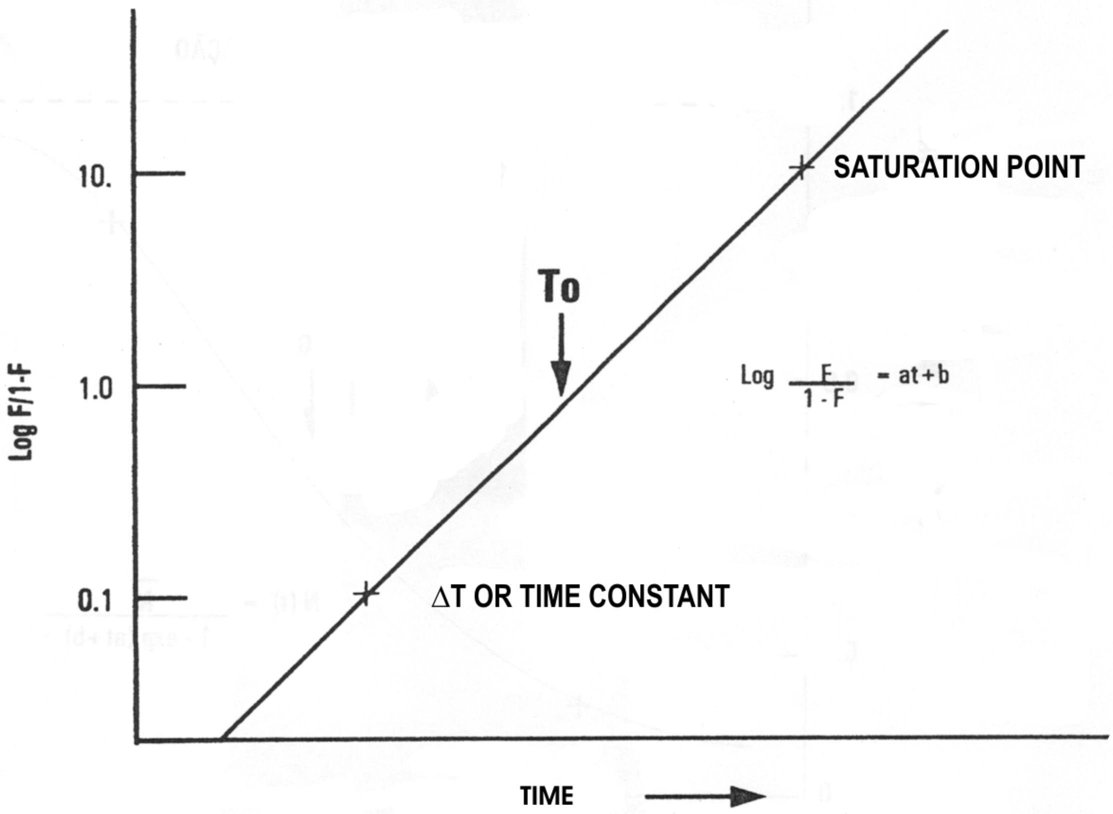


Figure 3

The central date, T_0, for any process, is defined as b/a. The number N*, which is, as it is known, a measure of the size of the niche, is also given in the title of every graphic display that summarizes the phenomena under examination.

The determination of the size of the "niche" N*, for a single competitor (for example for food gathering), is a delicate operation. For one single species, it can represent the totality of food available for consumption by the "intruder" species; the food is gradually exhausted transforming itself into additional individuals of the same species, as the growth of a single bacterial species in a culture broth. In some other cases the size of the niche is already physically defined, an example of which consists of the existing (or the constant exploitable function) of hydro-electric potential of a given country or region. But it is often obtained as the number that gives the best fit to the corresponding

Fisher-Pry linear representation (the one that presents the best correlation coefficient between variables).

When competition between two species is considered, their ratio evolution with time simplifies matters: one competitor decreases logistically at the same rate as the other competitor grows. It is assumed that the niche is initially filled by the first species. Therefore, F2 = (1-F1) and the size of the niche is consequently normalized to 1 (100%). It may happen that, as shown by Haldene (13), an intruder of another species 2, having a reproductive advantage k over species 1, will cause the ratio of the individuals of the two species to change in time by 1/(1-k) in each generation. If n is null (n= 0) at the initial moment (t=0), we can write:

$N1/N2 = R_o/ (1-k)^n$, where $R_o = N1/N2$ (5)

For small k, (typically of the order of 0.1 percent in biologic systems) we may write

$N1/N2 = R_o / e^{kn}$ (6)

We are thus back to equation (3), except for the fact that we have Ro as the initial condition, instead of N*. This means that in relative terms the evolution of the system is not sensitive to the size of the niche size which, as pointed out by Marchetti, is useful for forecasting (14)

To present a concrete application of the model, let us reconsider the description previously referred to of the plague that affected London, as presented in Figure 4. It shows the actual numbers of observed deaths, under the plausible assumption that the number of dead people remains a constant fraction of the number of the sick ones. The precision of the description of the events is simply fantastic. Once started significantly (1% of those already dead), the speed of propagation of the disease, as well as when it would end could be precisely predicted. It should be recalled that the propagation of the disease (by the logistic description) became extremely slow once 90% of the epidemic was reached. The process description at this phase is erratic, due to the large associated relative errors in the logarithmic scale (for N approaches N*). The system is said to “fibrillate”, a reminder of what often precedes heart failure, in cardiac diseases.

We do not need to add any further details concerning the relation between the epidemic process and the paradigms of action diffusion – including the most abstract ones – in society. It should only be remembered that when Marchetti examined the data presented by Mensch (6) (see Table 1 in Annex 1) in his study on the temporal evolution of innovations and inventions during 200 years, he demonstrated that contrary to generally strongly held conventional ideas, progress does not evolve continuously at increasing rates but in reality it follows a logistic like sequential wavy trajectory, as shown in Figure 5. This logistic Fisher-Pry behavior is shown in Figure 6.

The perfect synchronization between the number of innovations and the introduction of new primary energies onto the world market was also made evident by Marchetti as can be noted in Figure 7.

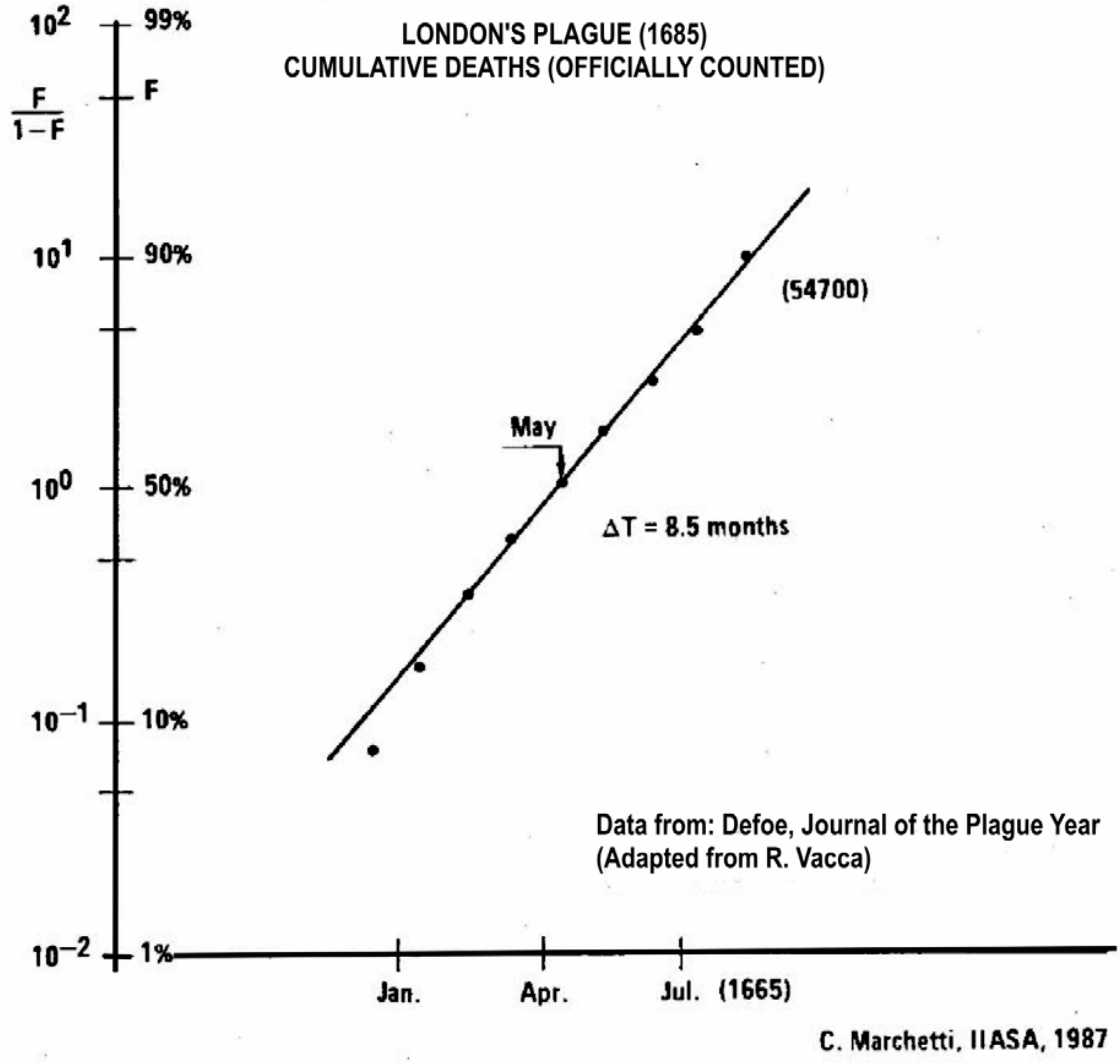


Figure 4

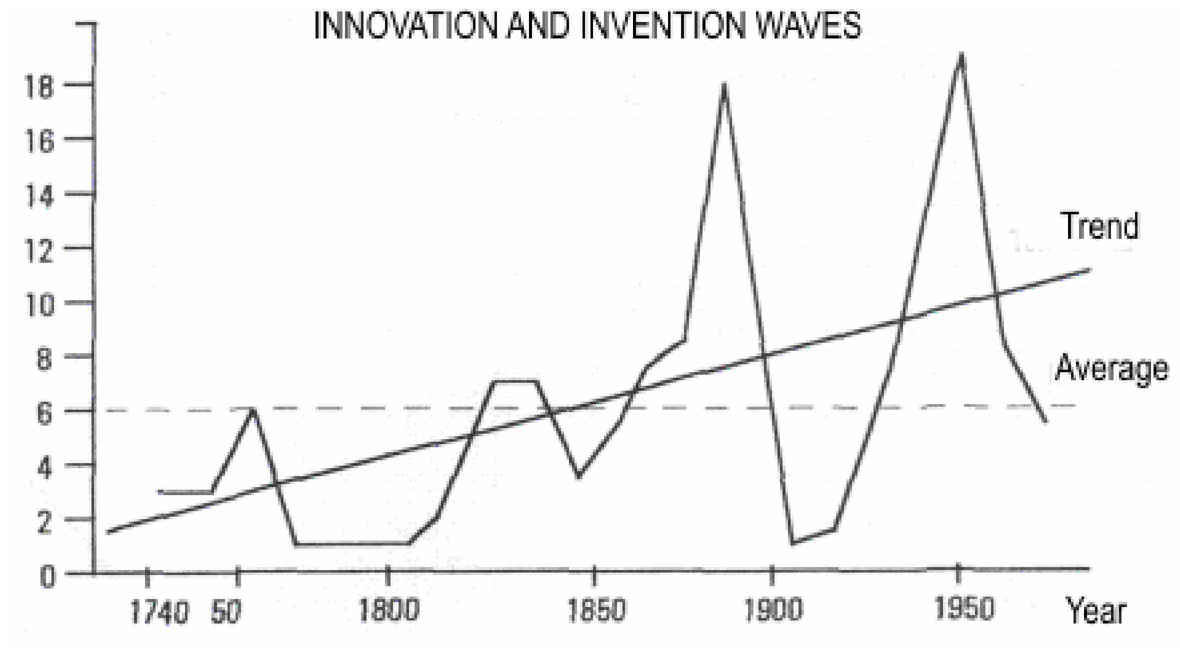
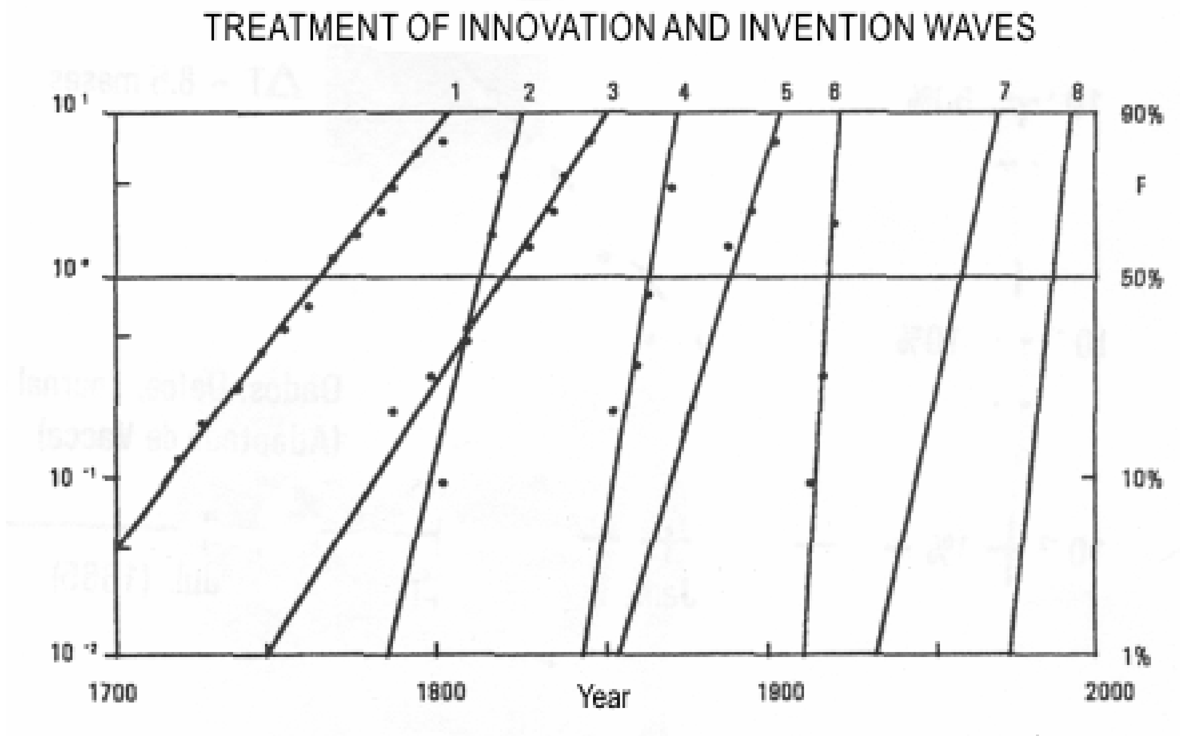
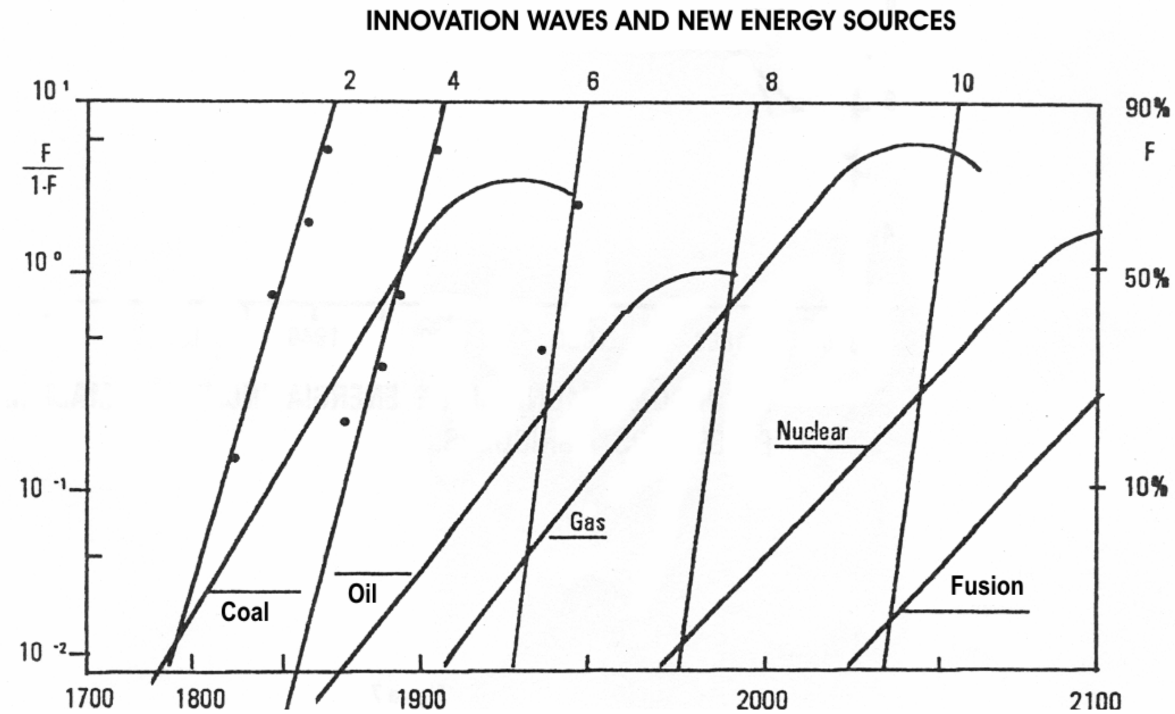


Figure 5



Odd-numbered curves refer to invention whereas those even-numbered refer to inventions.

Figure 6



Year

Odd-numbered curves refer to invention whereas those even-numbered refer to inventions.

Figure 7

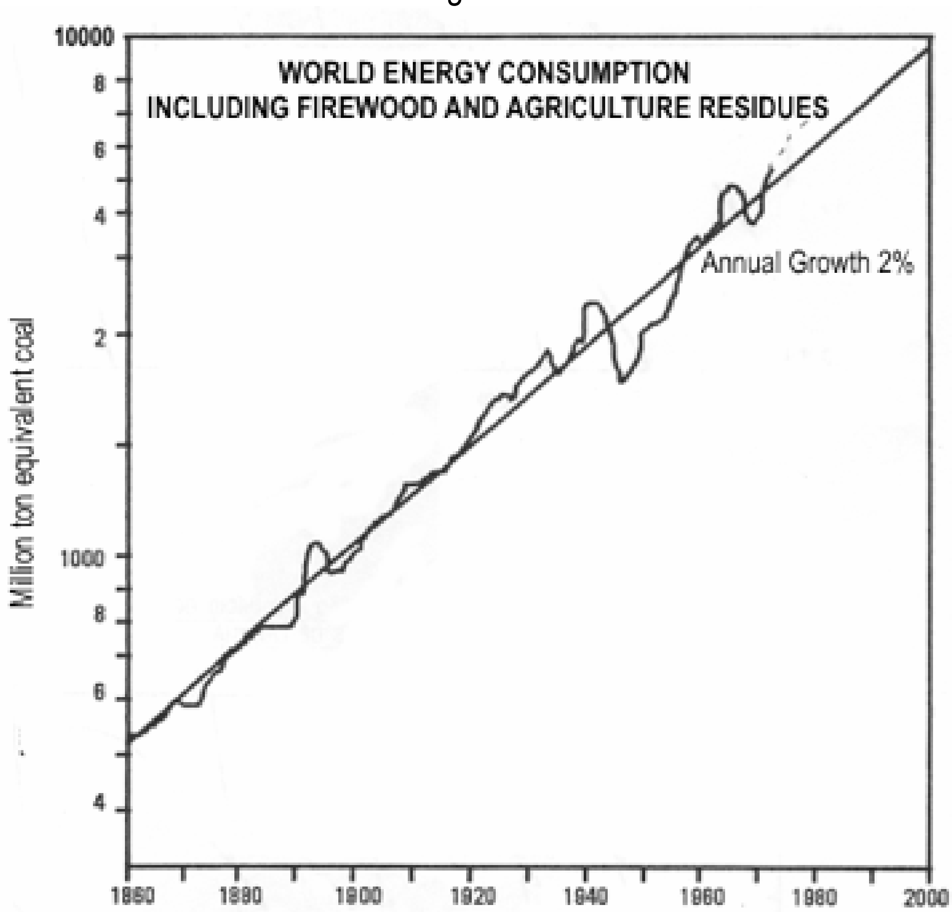


Figure 8

It became clear that total primary energy itself, penetrated the world market in an exponential way, typical of the initial phase of a logistic curve, as shown in Figure 8. For electric energy, the United States (Figure 9) and hydroelectricity in Brazil (Figure10), the respective market penetration is logistic.

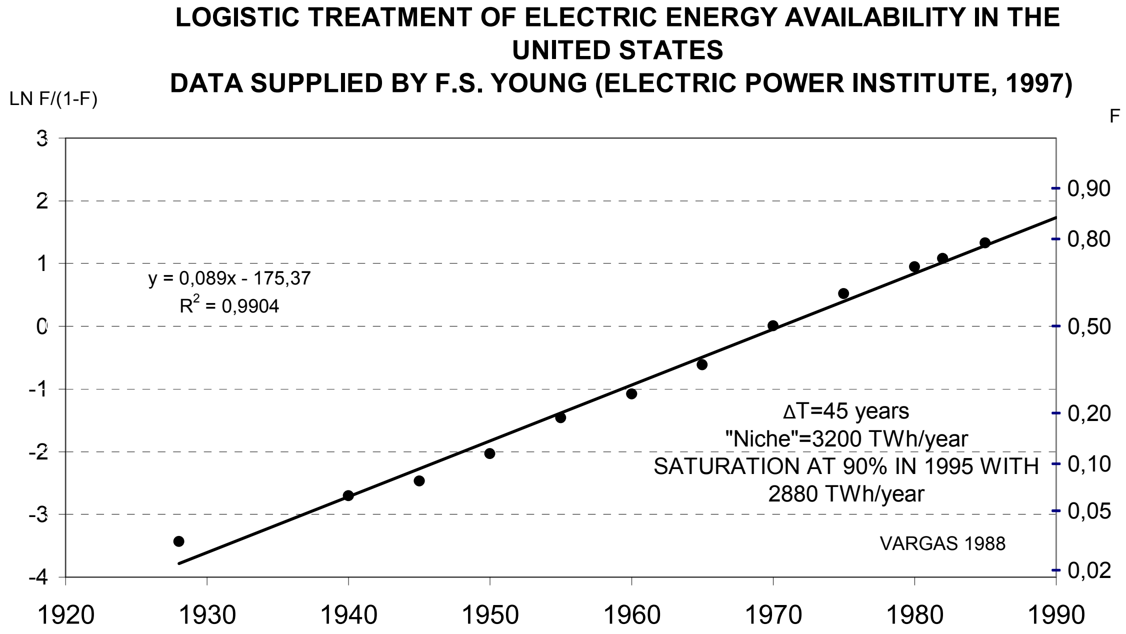
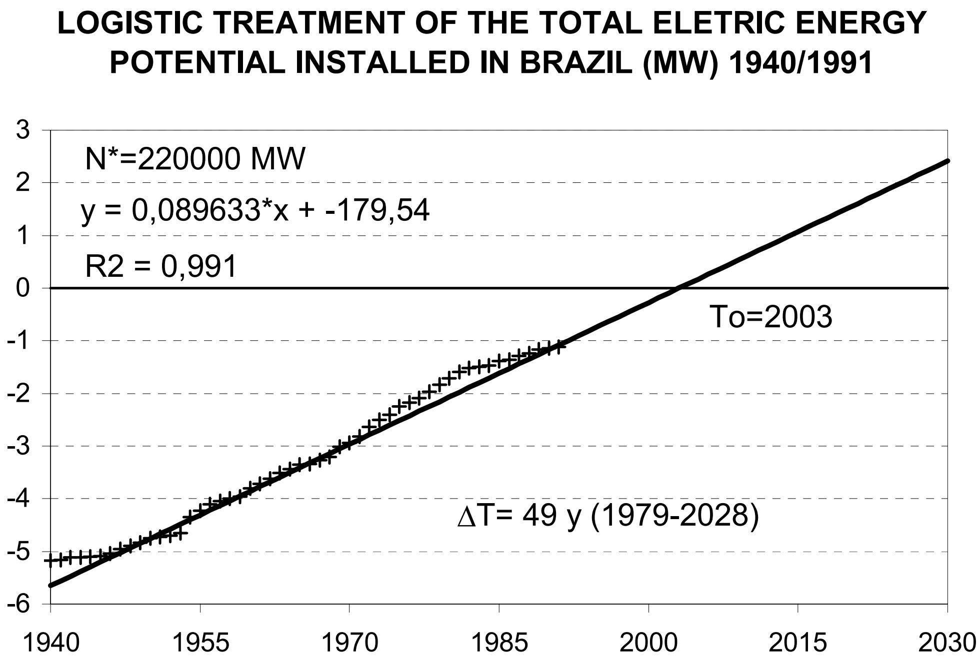


Figure 9

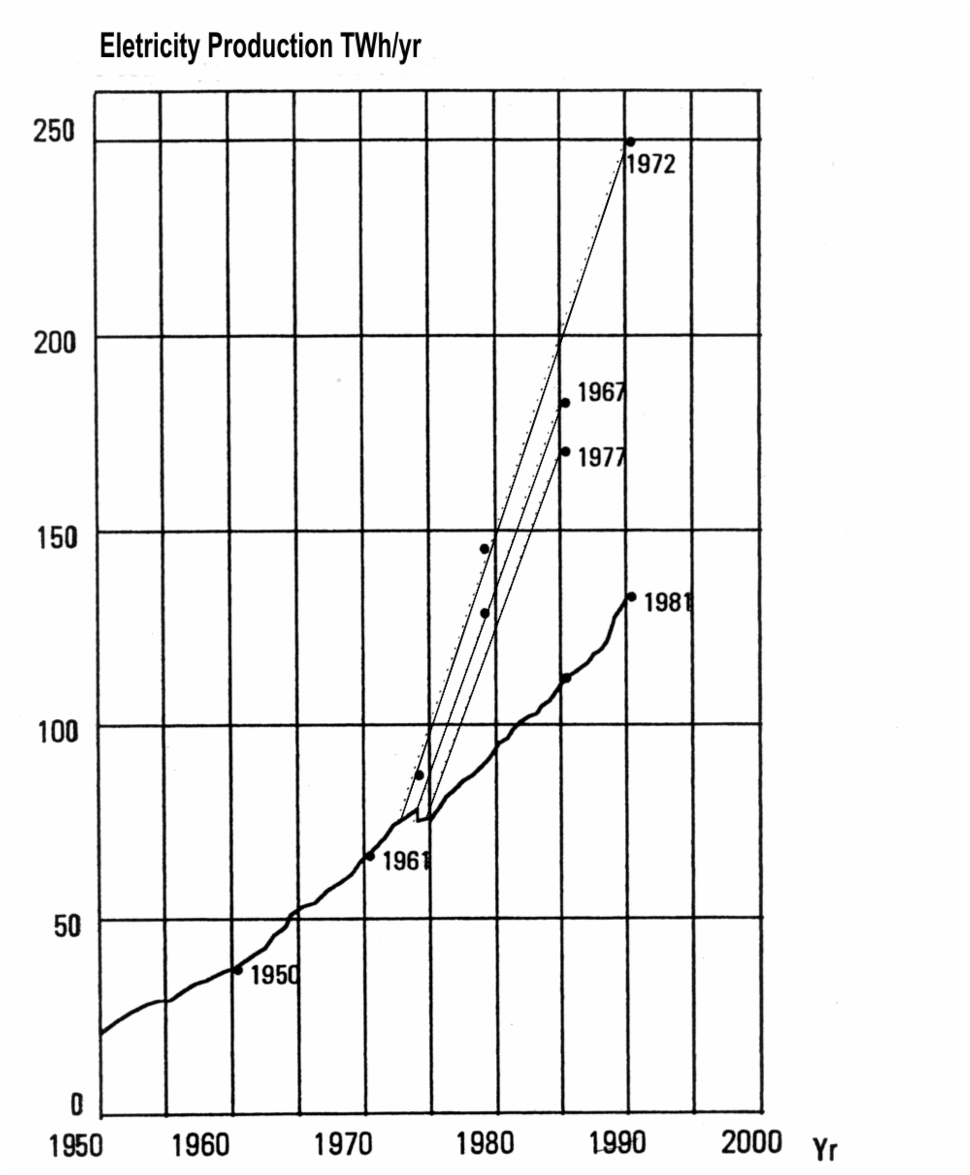


Dec 1991: Calculated: 55.6
Observed: 54,1

Dec 1994: Calculated 67,6
Observed: 57,6

Figure 10

The rather precise logistic description of the evolution of energy consumption and the prediction of their future performance, as shown in this figure, should be compared with the large errors observed in classical planning exercises, such as those conducted for Sweden (shown in Figure 11) or in Brazil (Figure 12), where excess energy was produced, in response to the wishes of exceedingly optimistic planners.[4]



The years shown in the graphic are those for which projection was made

Figure 11

In fact if due account had been taken of the longer term behavior of local economy erroneous conclusions would have been avoided. One of consequences of the Brazilian "economic miracle" is illustrated in Figure

4 Another example of mistaken forecasting resulted from having chosen a too short PNB time evolution, for calculation of the cement demand in Minas Gerais : a huge difference between estimated investments and those effectively called for was observed (unpublished analysis by the author).

12, where the evolution of installations, represented in boldface, considerably exceeds the logistic behavior as described by the curve.

Nevertheless, fluctuations in the logistic description of the primary energy growths themselves were observed to occur every fifty-five years, in close similarity to the long cycles that are supposed to affect economic activities. They were made well-known thanks to the Russian economist (Nicolai Kondratiev) who in 1928 anticipated not only the world economic crisis of the thirties but also those that periodically succeeded it.[5]

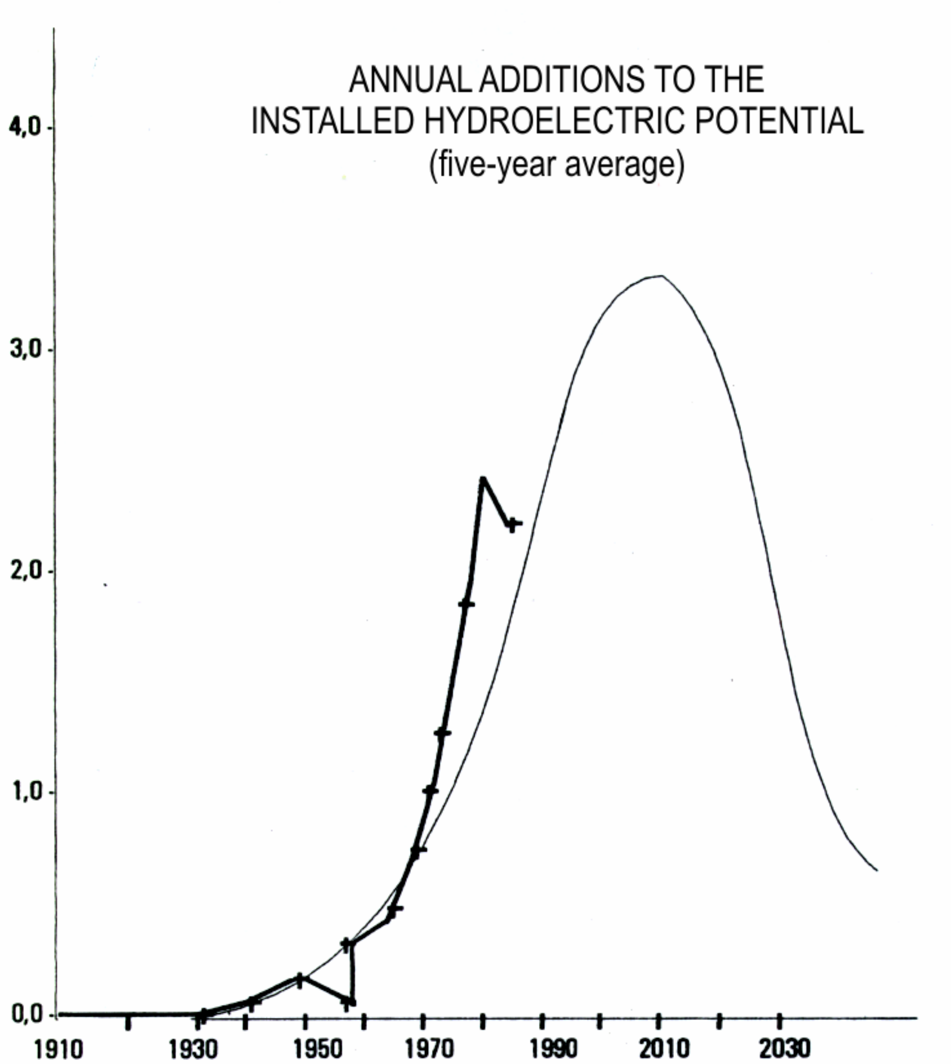
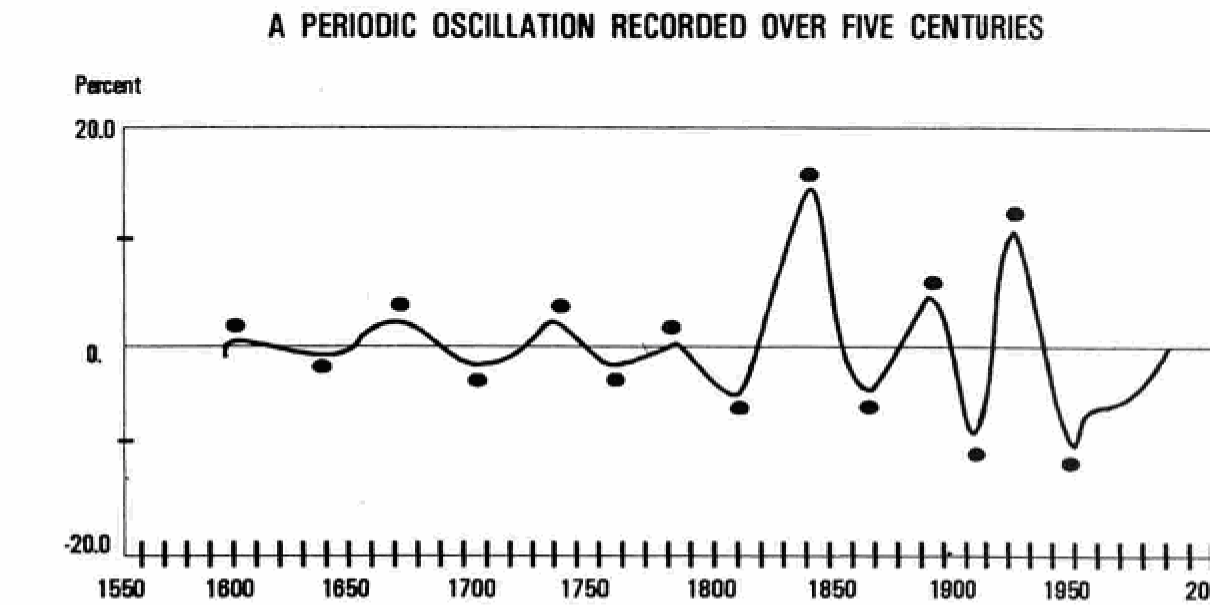


Figure 12

This periodicity on the behavior of the world economy was also observed to operate during the evolution of wholesale prices in England along five centuries, as referred by Modis (14). This behavior seems to confirm the existence of economic cycles in a major western market, as illustrated in Figure 13. For a review of this question see Paquett (16).

[5] According to Kondratiev , this would not be the last crisis of capitalism but the prelude of others that followed (15). This vision would cause him to be sent to the Gulag, where he died.

Recalling the definition of energy as the capacity to produce work, the examination of fluctuations in the consumption of this good could supply precious indications about the productive activity of society: larger use during economic booms while decreasing during recessions. The existence of these cycles, for energy consumption, was made evident in a study carried out by Stewart and displayed in Figures 14 and 15.



The U. K. Wholesale Price Index smoothed over a rolling 25-year period with respect a 50-year moving average. This procedure washes out small fluctuations and reveals a wave. The periodicity turns out to be 55.5 years

Figure 13

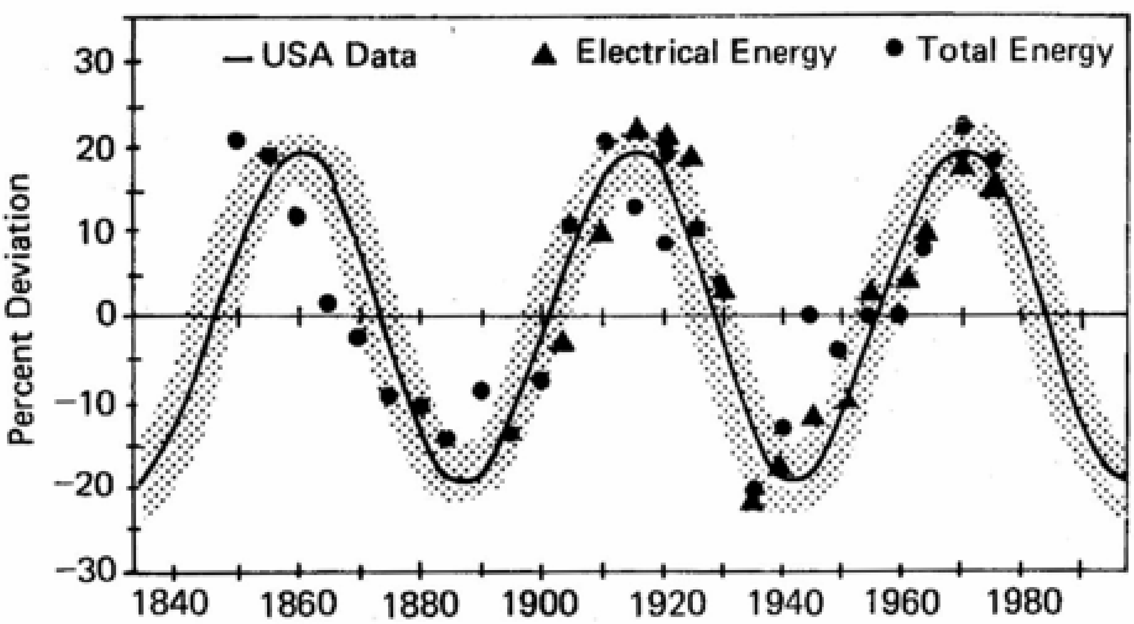
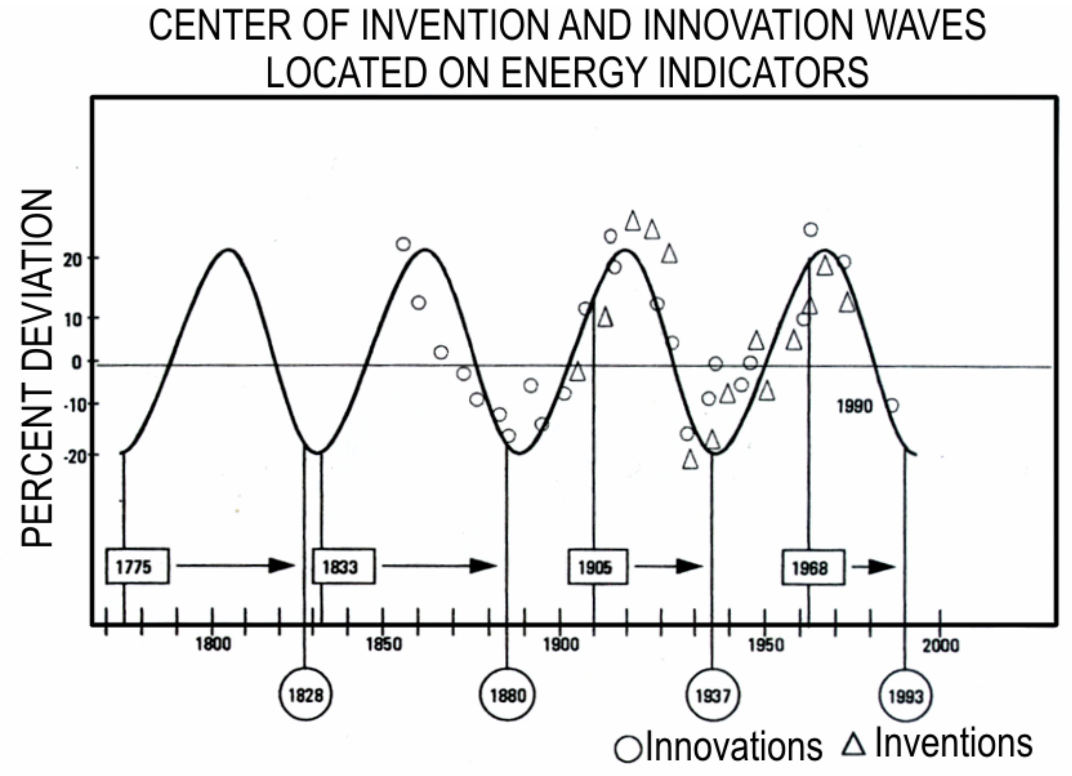


Figure 14



(The correlation with Mensch's data is due to Marchetti)
Figure 15

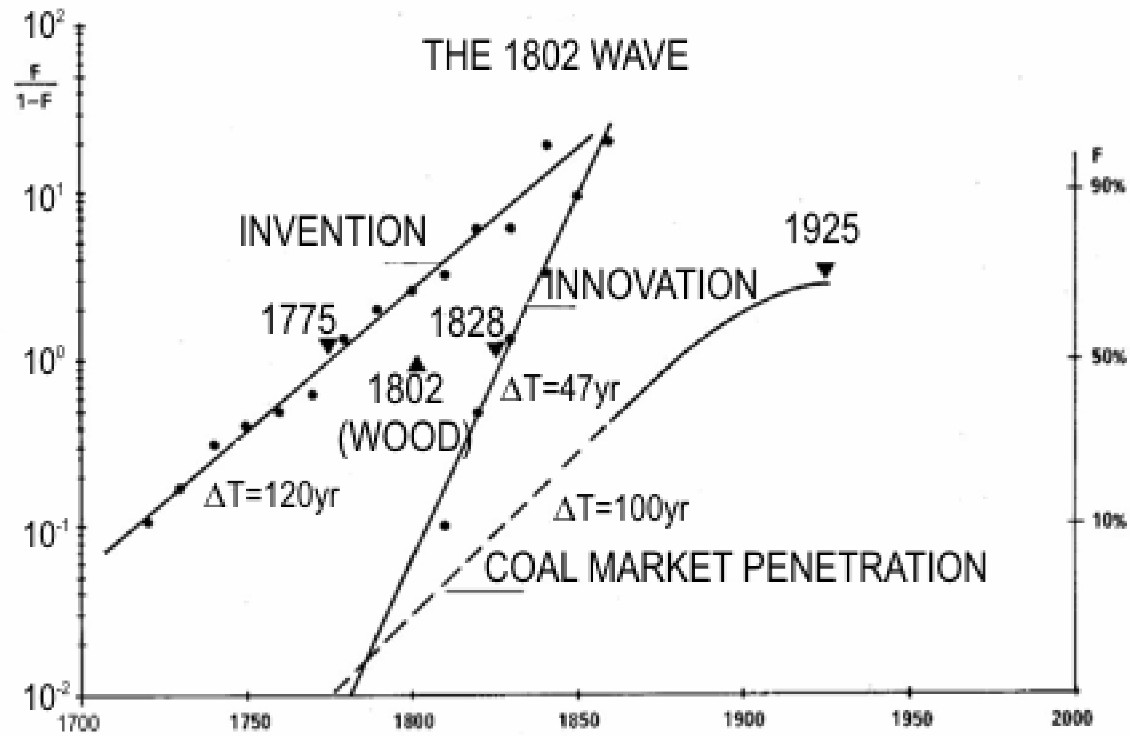


Figure 16

They represent the difference between the real primary energy consumption and the theoretical one, resulting from the best fit of the straight line obtained after the linearization of the logistic curve, in the Fisher-Pry representation. The phenomenon refers to the United States for the period from 1835 to 1995. We may, in fact, identify in the observed differences – that can reach 20% - the illustration of the occurrence of progress in the “glorious twenties”, as well as the recession of the eighties. (See note 1 that indicates equivalent behavior in Brazil)

Unfortunately, recession according to predictions of the model is bound to return right away, since the “world” system, as we well know is synchronized: what is true for the industrialized countries is true for Brazil, except for differences of phase that may manifest themselves in other countries.

The behavior of various social systems, as described by the logistic expression may reveal itself to be fractal. This means that the phenomena under scrutiny may be described by the same algorithm, regardless of their hierarchic level. Good examples of this behavior are displayed by the energy systems mentioned above: the equation bearing the same format describes the energy consumption growth for the United States and Brazil, respectively (Figures 9 and 10).

Let us examine in greater detail the synchronization of innovation/invention and energy, as shown in Figures 15 and 16. We notice that:

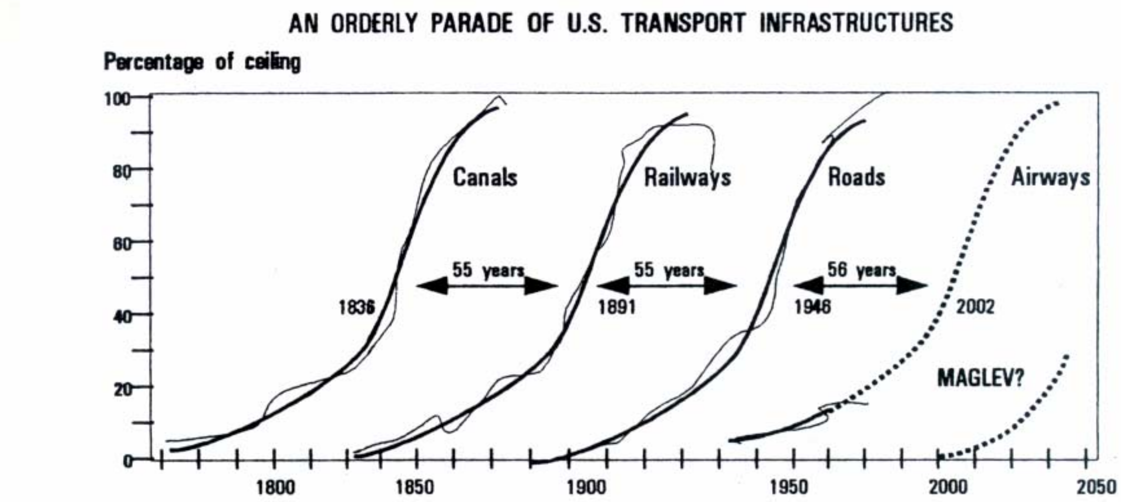
1) Inventions always occur during recession, in times of crisis, almost at the minimal values of the Kondratiev cycles as presented in Figure 17 (and made evident in Figures 15 and 16 that clearly show the connection between the maximum use of petroleum in 1980 and inventions-innovations – maximums values in 1968 and 1993, respectively). Quoting Guimarães Rosa: “O sapo pula não é por boniteza, mas por percisão” (The toad jumps not for fancy but for necessity).

The maxima of innovation waves display a time distance of 55 years, thus presenting the same periodicity previously referred to. The innovations that are typically shaping our own epoch reached their peak in 1993. This will allow us another ten years to get down to work… before they are repeated much later on.

2) The distance between inventions and innovations represented in the waves contracts progressively. The confirmation of this behavior can

be noted in Figure 5, where the growing narrowing between the curves representing inventions and innovations are shown. This feature has been often remarked independently of the model, reflecting perhaps the expectation that the growing reduction of these inventions and innovations time-lag are permanent. Inventions that are used nowadays did indeed occur in 1968.

In Figure 17 another remarkable example, among hundreds analyzed by Marchetti and collaborators is to be highlighted. It further reinforces the evidence in favor of the reality of the long Kondratiev cycles. The figure describes the sequential dissemination of three basic transport technologies, in the U.S.A, over more than one century: the construction of water channels, railways and roads, frequently displaying overlapping stages; more recently, air transportation also emerges gradually as a significant competitor. The representation is purely logistic (S shaped), the ordinate describing the “niche” occupation is expressed in percent. Within the time span under consideration, the process refers to the occupation of the whole country. The same phenomenon is presented in logarithmic scale in Figure 18, making clearer the pointed out competition.



The growth in length of each infrastructure is expressed .... percentage of its final ceiling. The absolute levels of these ceilings in miles are quite different (see text). For airways the ceiling has been estimated. The percent levels of these growth processes are regularly spaced 55 to 56 years. A future infrastructure (called Maglev) may start sometime around the ... the century, but its halfway point should be rather close to 2058.*

***Adapted from a graph by Arnulf Grubler in *The Rise and Fall Of Transport* Infrastructure (Heidelberg: Physica-Verlag, 1990), excluding the lines labeled "airways" and "Maglev?"** Reprinted by permission of the publisher.

Infrastructure	Ceiling (total mileage)
Canals	4,000 miles
Railways	300,000 miles
Roads	3,4 million miles
Airways	3,2 milion miles (estimated)

Figure 17

For the sake of curiosity, the competition of these technologies is identical to the one observed for the Russian niche. Indeed, the present modeling tool worked equally well for the old communist system, as shown in Figure 19 in logarithmic scale.

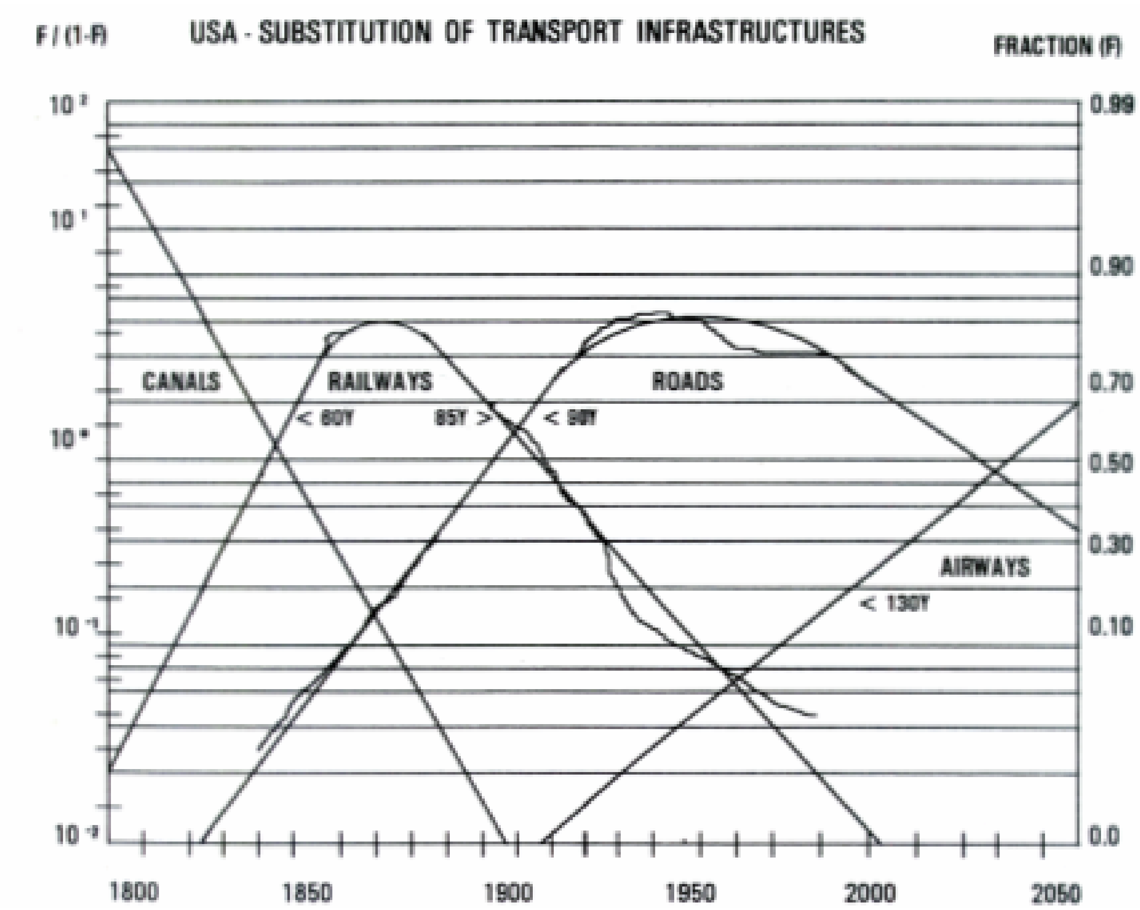


Figure 18

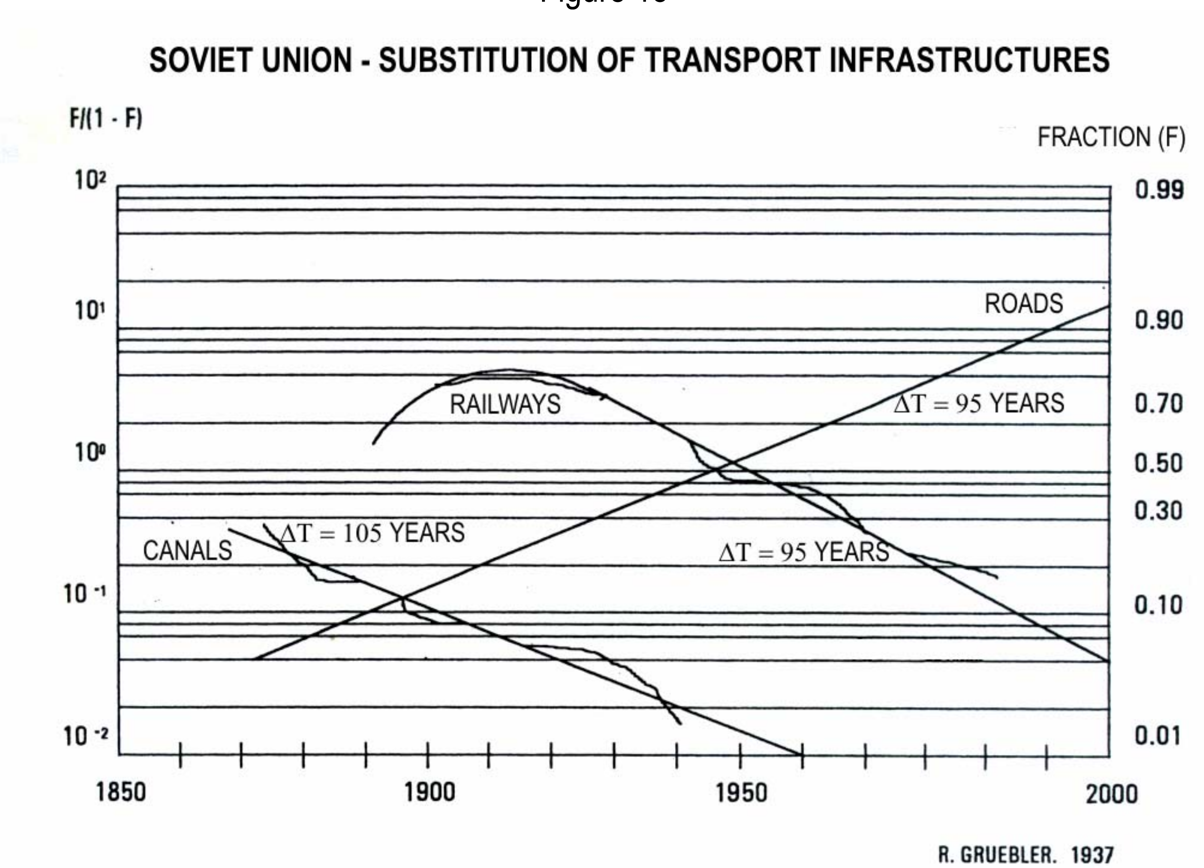


Figure 19

Another remarkable feature to be pointed out, that confirms these observations, is that primary energy replacement both in the United States (since 1850) and in Brazil follows the same logic or laws (as shown in Figures 20, 21 and 22). The increasing participation of natural gas on the global energy market should also be noted.

It should be stressed that any technology having penetrated more than 2-3 % of a given market and displaying certain competitive advantage (greater efficiency) as compared to other competing technologies, will inevitably conquer the market at the appropriate and predictable time, even if it started at a rather low level.

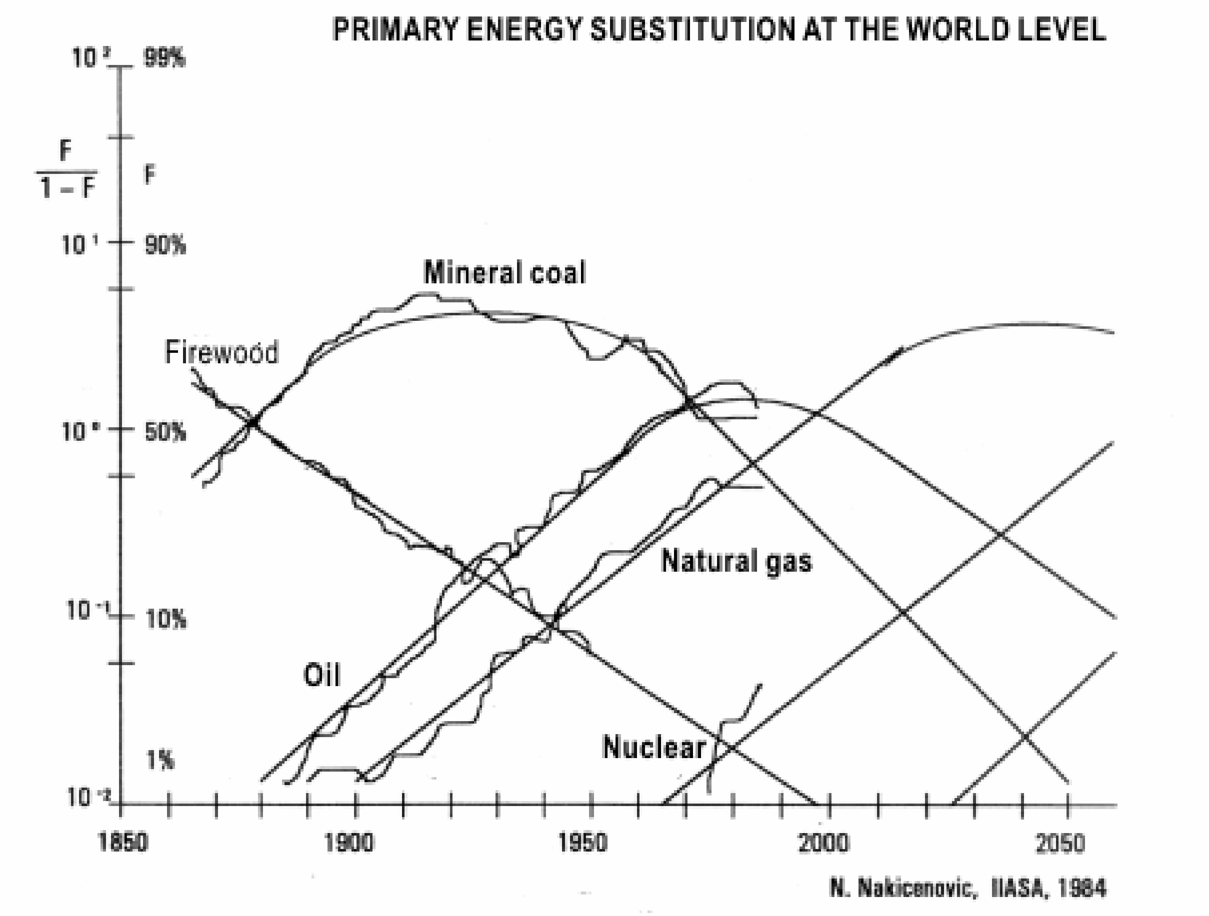
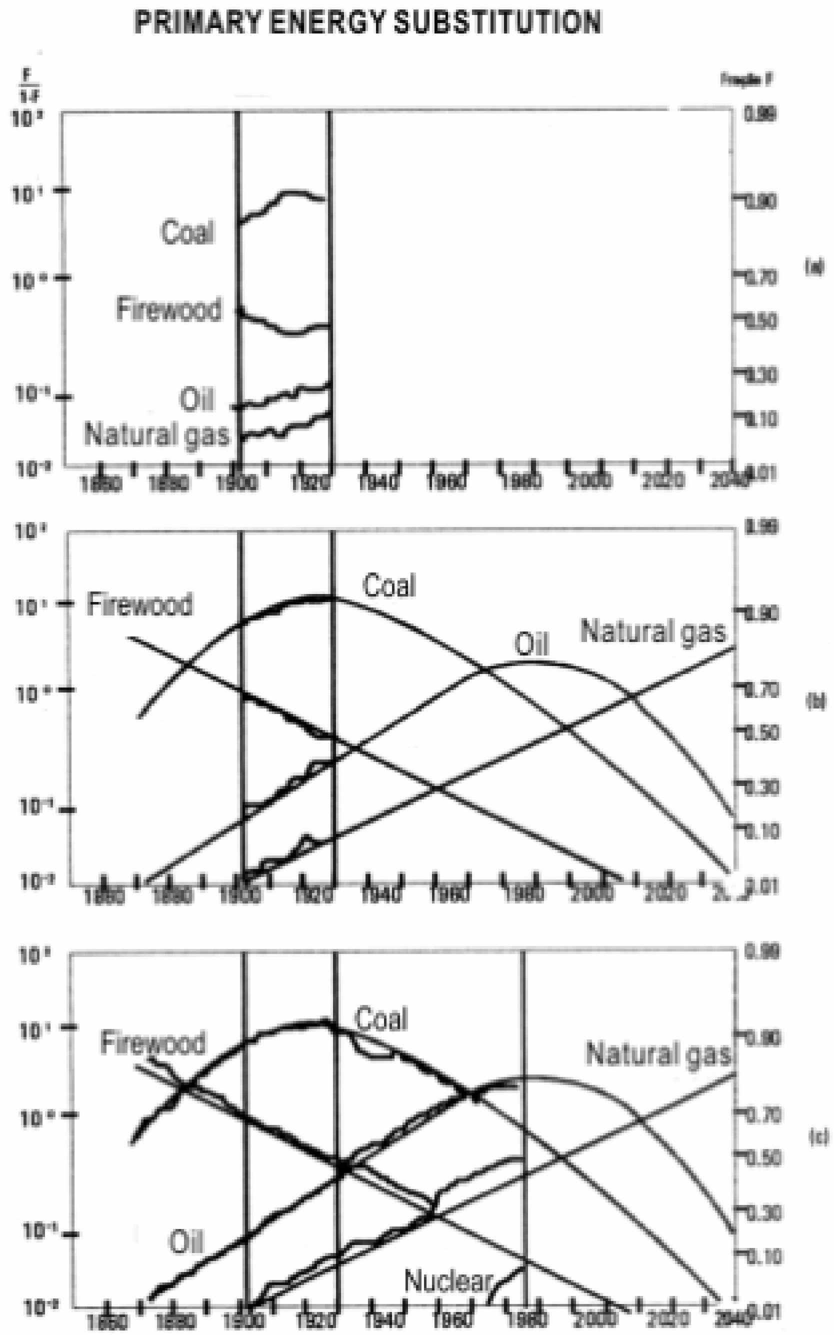


Figure 20



Ex-post facto forecasting carried out by Marchetti: data in the figure on top refer to years between 1900 and 1920 (a); using the model both past and the future were calculated regarding primary energy participation (b). The results were compared with actually observed (c).

Figure 21

So it can be noted that the sequential substitution processes of primary energies are extremely long. Let us recall that nuclear energy, already accounting for more than 5% of the total world primary energy consumption, has reached a 15% share in electricity generation after 50 years of its introduction. Therefore, the model predicts that its participation shall continue to grow despite the fierce opposition of environmentalists who do not take into account such a long time taken to reach the appointed levels, as well as the overwhelming economic and strategic importance it enjoys in the modern world.

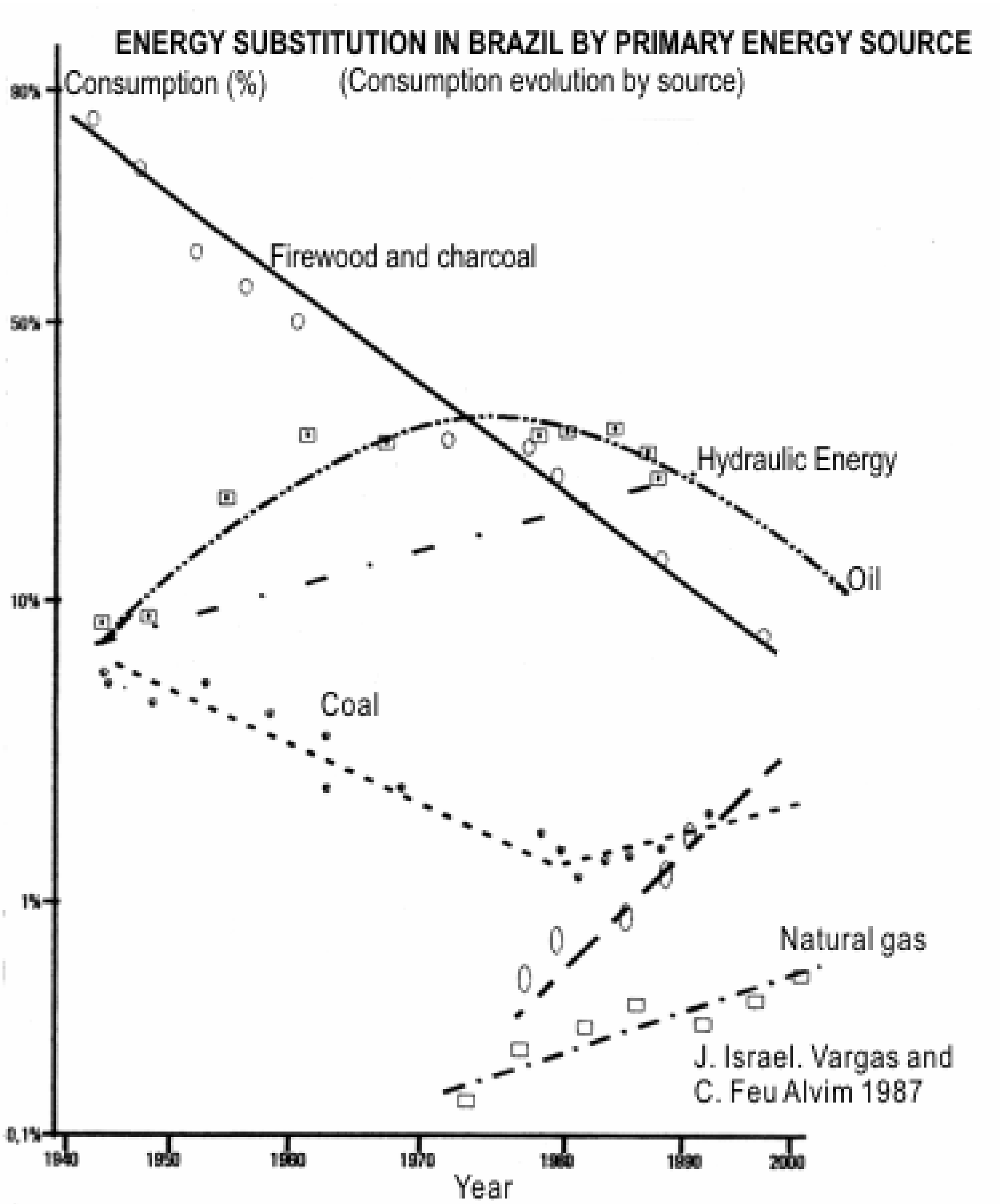
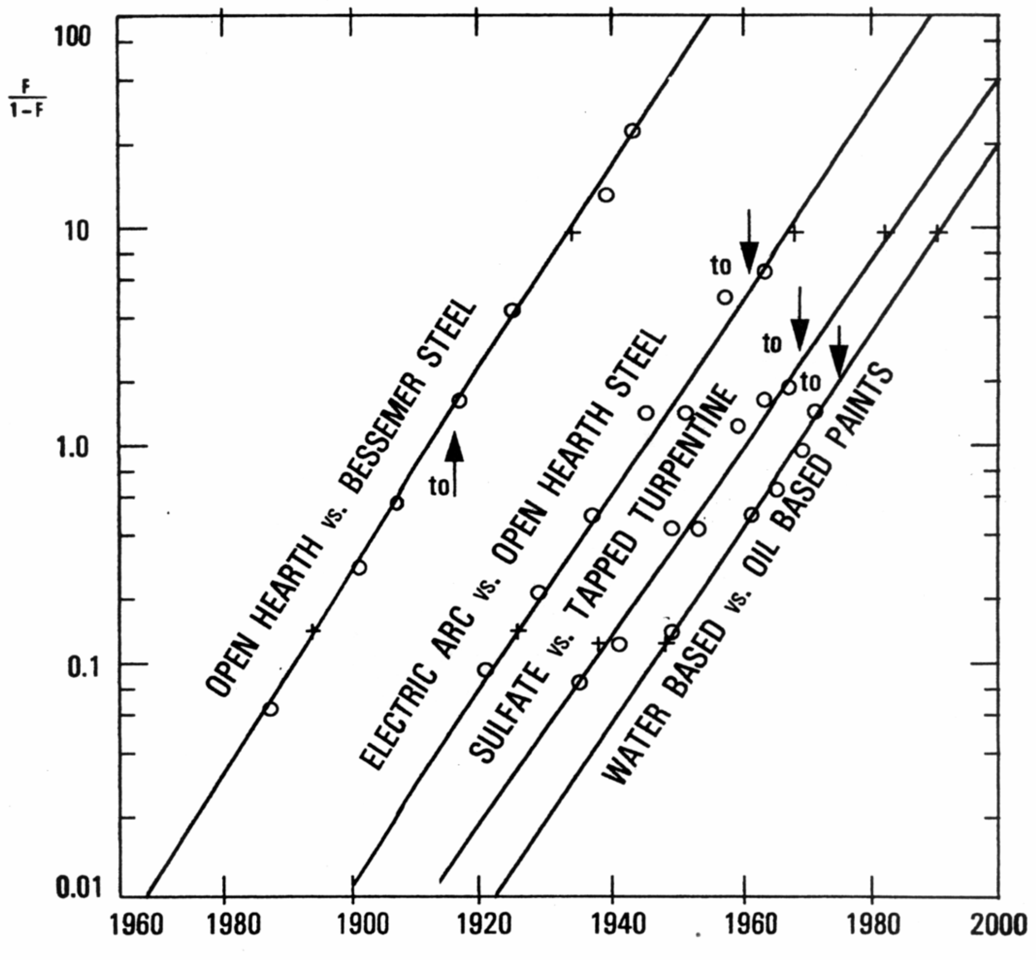


Figure 22

Contrary to ordinary expectations and proclaimed common sense, the development of social systems and of technologies is always stable, predictable and slow. Its behavior is eminently regular. Incidentally, the evolution of primary energies along almost one and a half century, shown in Figures 20, has undergone only slight changes as a consequence both of the great economic crisis in 1930, and the upheaval caused by two world wars. The resulting disturbances in the use of these energies, due to the appointed events, have been rapidly reabsorbed, following each one of them the path anticipated by the model. This behavior is therefore homeostatic, the same displayed by living species.

We insist that all these systems work as if governed by an inflexible, deep rooted internal logic that would command not only the “hard systems” but also those involving “soft” technologies as well as those connected with essentially intellectual activities. We repeat, in contradistinction to current expectations, everything evolves very slowly indeed.



Market penetration curves in the U.S.
(From J. Fisher and R. H. Pry)

Figure 23

Figure 23 displays that, as happened with technologies as “hard” as the new technologies for producing steel, the market occupation by “soft” technologies is equally sluggish. It should be noted, for example, that the “soft” technology involved in the transition, from oil-based painting to the water-based one has lasted as long as the technical changes involved in steel fabrication (50 years in both cases). The following are also interesting examples of model application to purely “soft” systems:

a) The building of gothic cathedrals, that lasted for almost two hundred years, as described by Marchetti and shown in Figure 24.

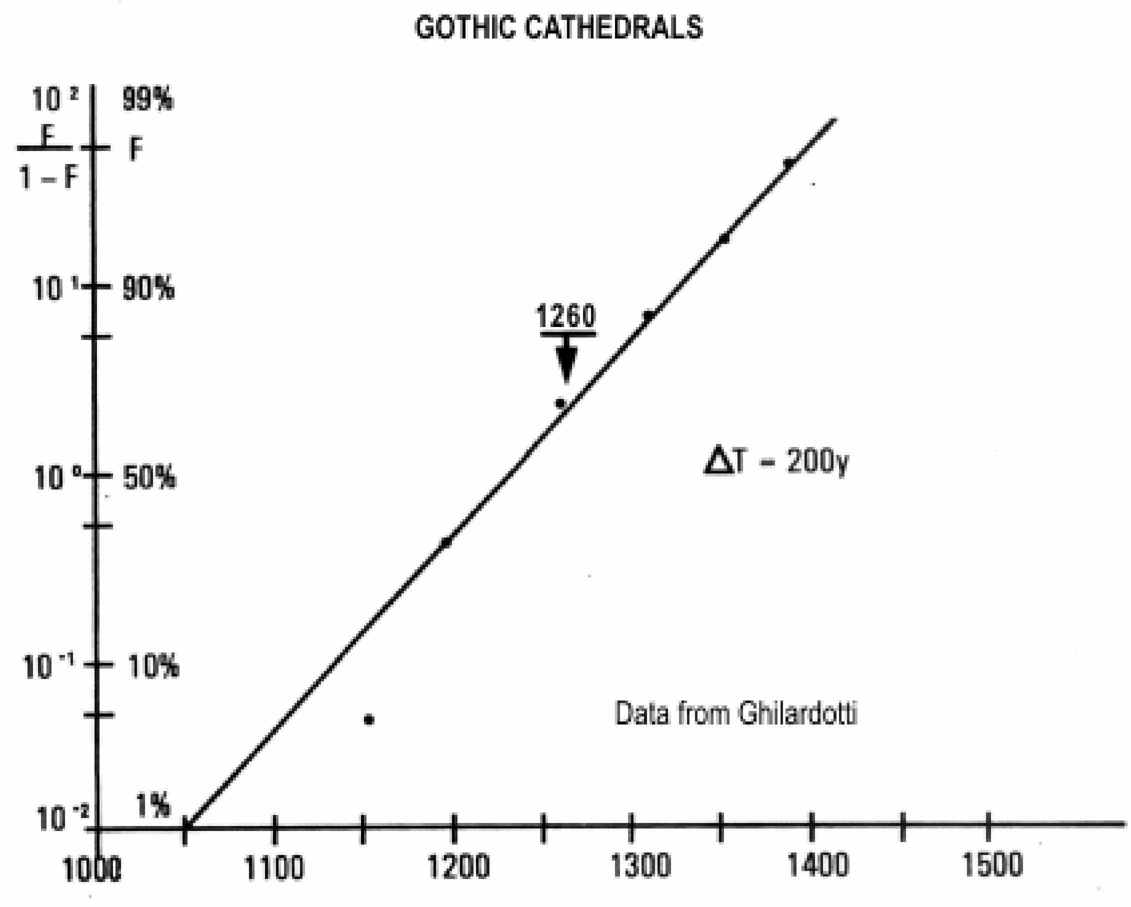


Figure 24

b) Inspired by this surprising example, the evolution in the building of baroque churches in Ouro Preto and in Mariana (17), during the 18th and 19th centuries, was examined by this author. The result may be seen in Figures 25 and 26.

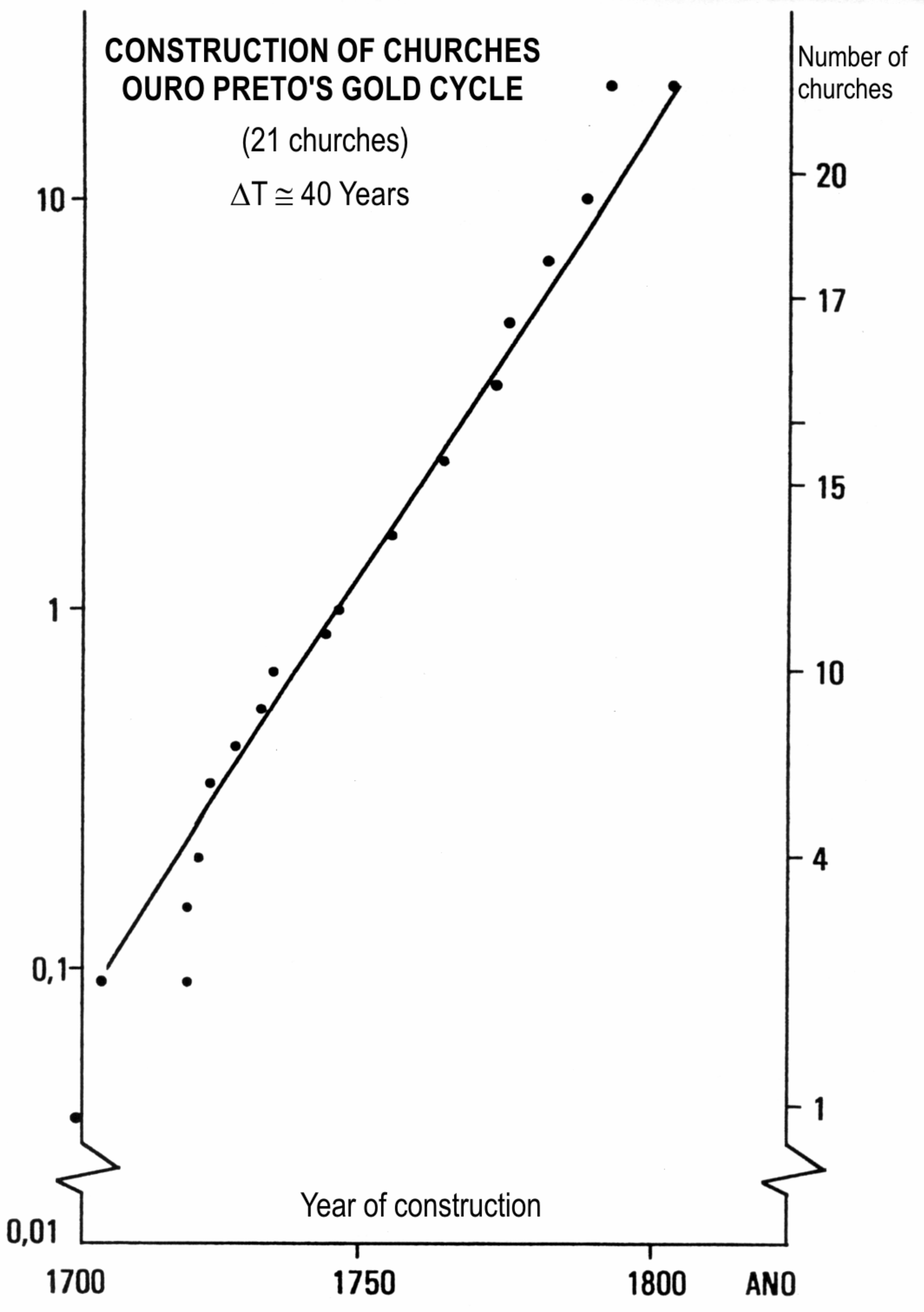

CONSTRUCTION OF CHURCHES
OURO PRETO'S GOLD CYCLE
(21 churches)
ΔT ≅ 40 Years
Number of churches
10
1
0,1
0,01
20
17
15
10
4
1
Year of construction
1700
1750
1800
ANO

Figure 25

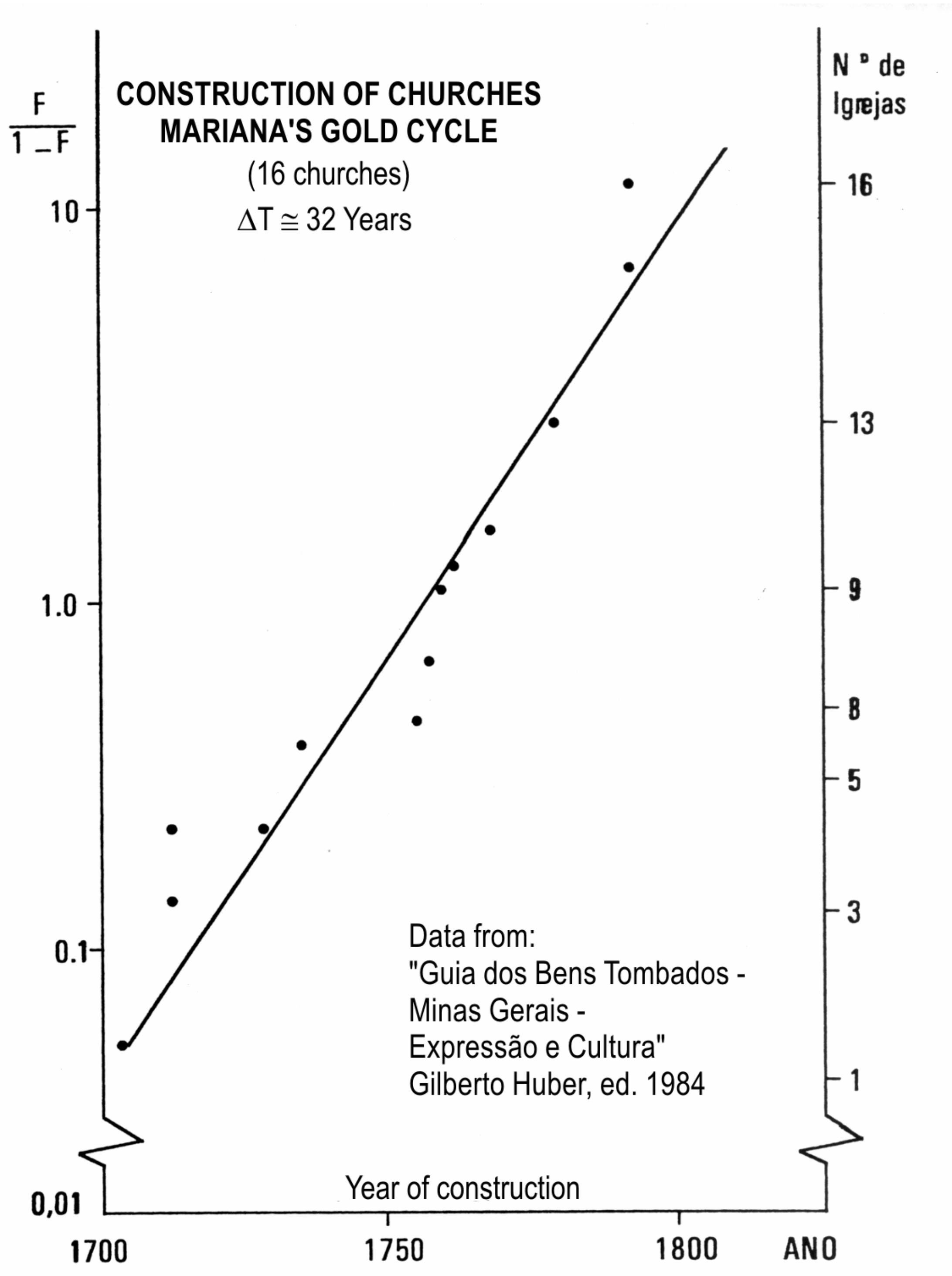


Figure 26

Due to the obvious connection with the subject, the parallel evolution of gold production in Minas Gerais in the same Colonial era, is also presented in Figure 27. The accelerated rhythm of church building coincides perfectly with the peak of gold production (1750). When gold was discovered, building churches became rapidly the main economic activity in the region. At the beginning of this extraordinary saga,

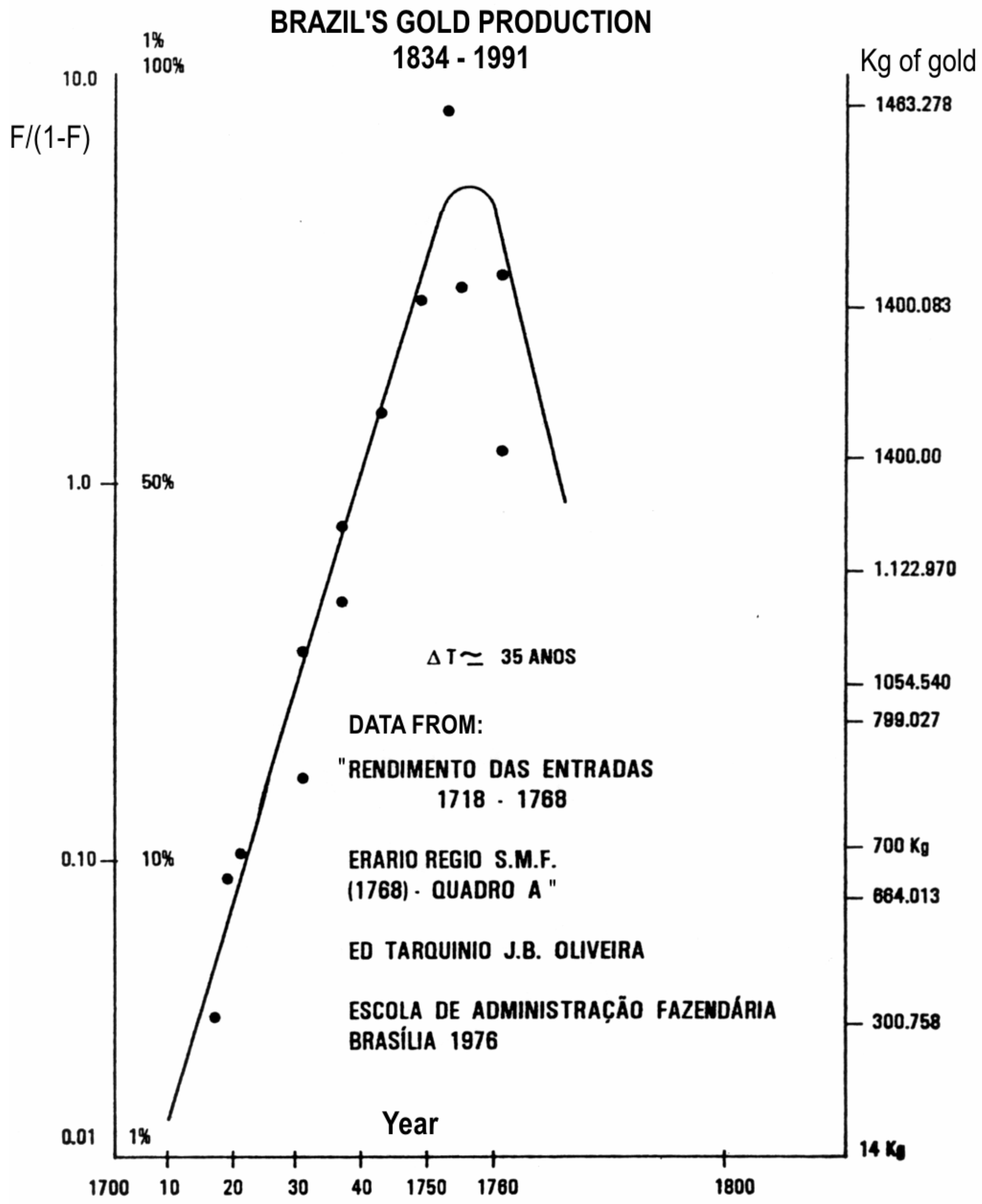


Figure 27

churches were built, presumably to thank Providence for the happy finding; subsequently it became indispensable to keep on mining, in order to sustain the well known Fraternities that hired masons, painters, musicians, including the extraordinary musician Lobo de Mesquita, and Aleijadinho himself, the greatest sculptor of the Americas. In São João del Rei, Minas, was also founded the first symphony orchestra of the Americas (18). Gold made society tick… Later on, by the end of the nineteenth century, gold production was virtually finished and church building came to a stand still. But what was exhausted? The faith? In fact it was the alluvium gold that was exhausted, exploitable subsequently only by the new technologies. Having been left behind by the industrial revolution, Portugal (and Brazil) could not count on any of the contemporary paradigmatic emerging technologies, such as steam engine machines, associated with chemical extraction, etc… Actually, later on these technologies were utilized in the Morro Velho Mine that, for over a century and a half was, not surprisingly, British owned. It is not surprising that gold exploration in this mine followed the same logistic behavior (Figure 28) described here. Incidentally, it is claimed that Ouro Preto (Black Gold) owes its name to the presence of new chemical element – palladium, discovered in 1803 and later found in the Minas Gerais bullions (19).

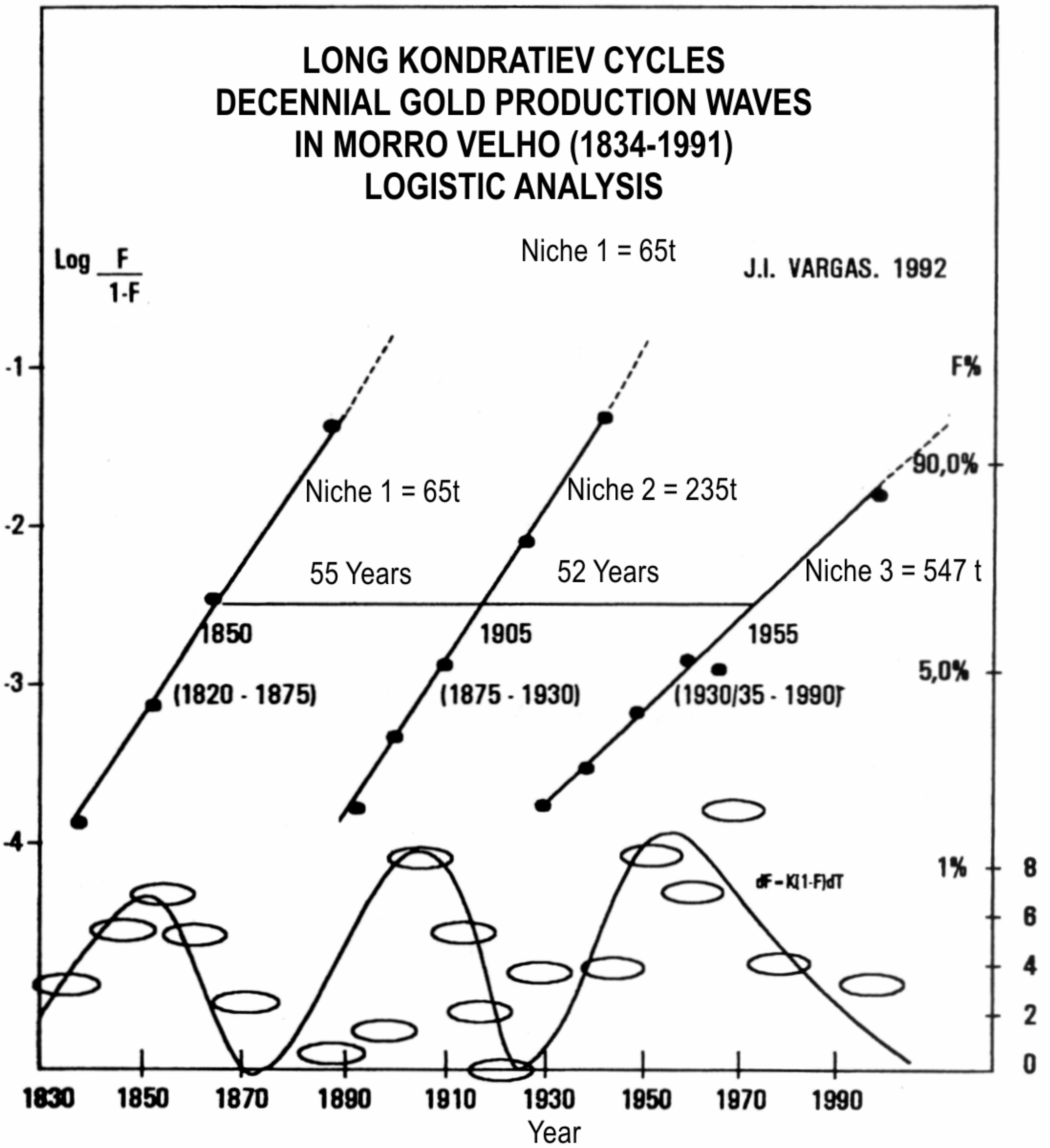


Figure 28

c) The saga of the discovery of the chemical elements by scientific community involved in the frenetic demolition of molecules, to identify, along two hundred years, the supposedly ultimate constituents of matter -the atom – (from Leucipo and Democritus on) is shown in Figure 29. For that purpose, during hundreds of years, particularly during the 19th century, scientific associations were created, papers were published, laboratories and institutions were established and thousands of individuals were mobilized. The number of people involved increased epidemically, until, of course, the available, naturally limited "niche", was emptied, with the completion of the identification of all existing atomic species (20). With Rutherford and a long list of followers working around the clock, a new style was soon inaugurated: the fragmentation of atoms, their nuclei, in search for the subatomic particles, called subnuclear particles. This urge to look deeper and deeper into matter goes on and on; but this is another story to be told elsewhere.

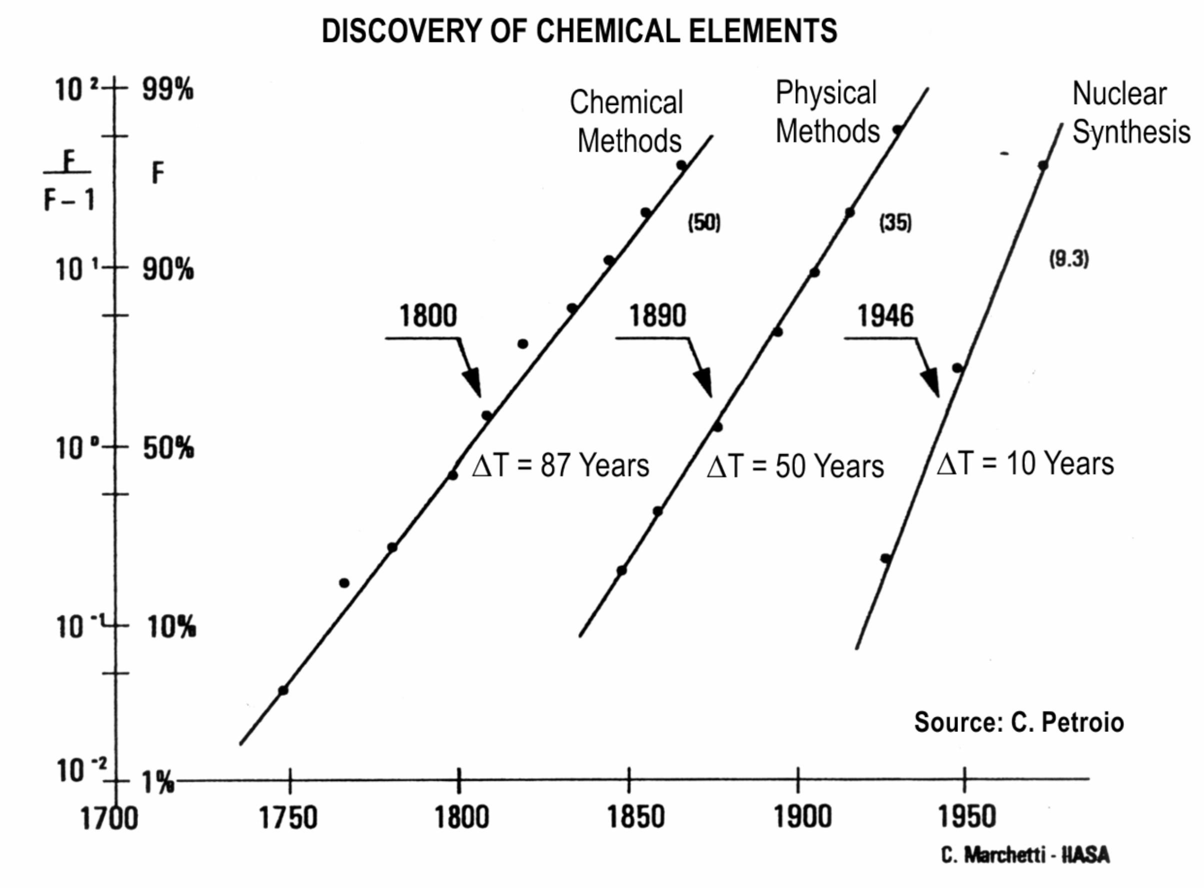


Figure 29

TABLE 1
EXAMPLES OF INVENTION - INOVATION CYCLE FROM 1857 TO 1910

	Invention	Innovation
Thomas steel	1855	1878
Safety matches	1805	1866
Aniline dyes	1771	1860
Cooking fat	1811	1882
Indigo synthesis	1880	1897
Sodium carbonate	1791	1861
Aluminum	1827	1887
Refrigeration	1873	1895
Rayon	1857	1890
Gas heating	1780	1875
Oxyacetylene welding	1862	1892
Dynamite	1844	1867
Chemical fertilizer	1840	1885
Preservatives	1839	1873
Electrolysis	1789	1887
Antitoxin	1877	1894
Chloroform	1831	1884
Iodoform (antiseptic)	1822	1880
Veronal (barbiturate)	1862	1882
Aspirin	1853	1898
Phenazone (synthetic painkiller)	1828	1883
Baking powder	1764	1856
Plaster cast	1750	1852
Mass production of sulfuric acid	1819	1875
Synthetic alkaloid (cocaine)	1844	1885
Synthetic alkaloid (crinoline)	1834	1880
High grade steel	1771	1856
Electrodynamic measurement	1745	1846
Lead battery	1780	1859
Double armature dynamo	1820	1867
Commutator	1833	1869
Cylinder armature motor	1785	1872
Arc lamp	1802	1873
Incandescent light bulb	1800	1879
Electric locomotive	1841	1879
Electric heating	1859	1882
Cable construction	1820	1882

TABLE 1 EXAMPLES OF INVENTION - INOVATION CYCLE FROM 1857 TO 1910		
	Invention	Innovation
Telephone	1854	1881
Steam turbine	1842	1884
Water turbine	1824	1880
Transformer	1831	1885
Resistance welding	1841	1886
Arc welding	1849	1898
Induction smelting	1860	1891
Metes	1844	1888
Electric railroad	1879	1895
Long-distance telephoning	1893	1910
High tension insulation	1897	1910
Gasoline motor	1860	1886

Source: Mensch (6)

Annex Note 1:
The fluctuations in the American market analyzed by Fischer and Pry and shown in Figure 14 also occurred in Brazil, as shown in Figure N1.1 for the 1952 – 2000 time period, demonstrating that the country is still under recession, that presumably will start its reversion at the start of the new century.

`

DEVIATION OF ELECTRICITY CONSUMPTION IN BRAZIL COMPARED WITH THE LOGISTIC FITTING (MOVABLE AVERAGE OF THREE YEARS)

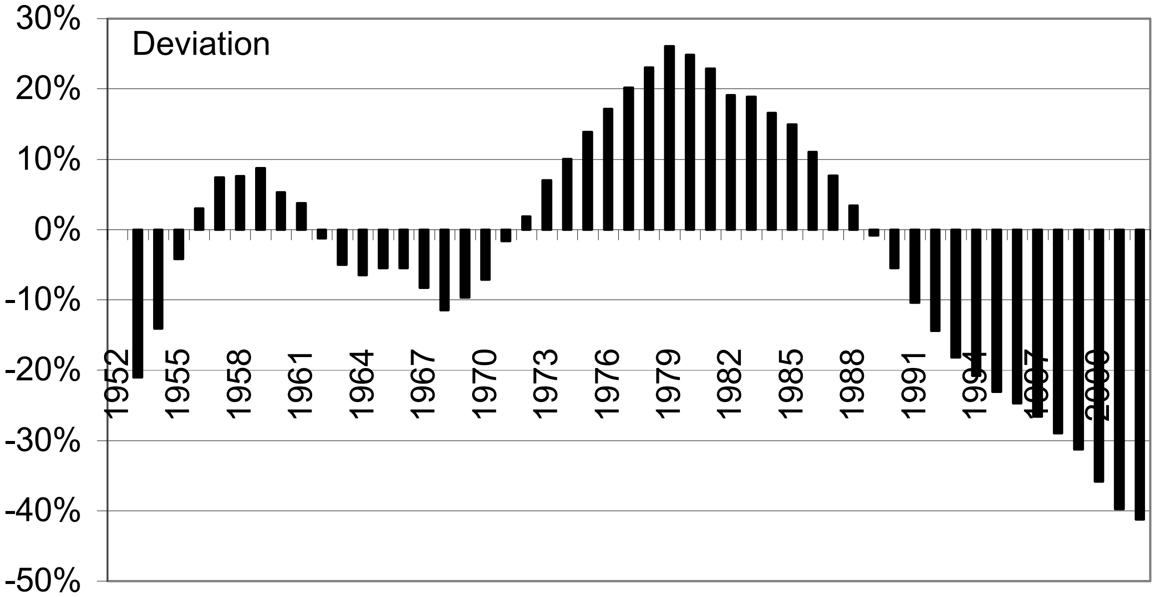


Figure N1.1

In the next issue: Scientific and technological quantitative behavior along time: predictions (conclusion)

References:

1. Volterra, V., "Leçon sur la Theorie Mathematique de la Lute pour la Vie". Paris, Gauthier – Vilars, 1931

2. Lotka, A. J., Elements of Physical Biology. Baltimore M.D.: Williams & Wilkins Co. 1925.

3. Verhulst, P. F. "Recherches Mathematiques sur la Loi de l'Accroissement de la Population". Nouveaux Memoires de l'Academie Royale dês Sciences et de Belles Lettres de Bruxelles 18 (1845).

4. Montrol E. W. and Goel, N. S. "On the Volterra and other Nonlinear Models of Interacting Populations". Review of Modern Physics, 43 (2), 1971 and also Montrol, E. W. and Badger, W. W. "Introduction to Quantitative Aspects of Social Phenomena" (Gordon and Beach Science Publishers, 1974.

5. Nakicenovic N., "Technological Forecasting and Social Change", 29, 309-40, 1986.

6. Mensch, G., "Stalemate in Technology: Innovation overcomes the Depression", Cambridge, M A , Billinger Ed., 1979.

7. Fischer, J. C. , and Pry, R. H. "Technological Forecasting and Social Change", 3, No 1, 75-88, 1971

8. Schumpeter, J. A. "Business Cycle", McGraw-Hill, New York, 1939.

9. Vargas, J. I. in "Science, Technology and Development Action and Some Human Resources Issues in UNESCO". Unesco Colloquium on Science and Technology for the Future in Latin America, Mexico City, 2-6 December 1990.

10. Vargas, J.I. , "The Brazilian Energy Scenario", United Nations Conference on Environment and Development, Unesco- Organized Scientific Session, Rio, 1992.

11. Defoe, D. Journal of the Plague Year (Adapted by Vacca) – Apud C. Marchetti – IIASA, 1987

12. Marchetti, C. , “A Forecasting Model for Research and Innovation Activities in Selected Areas: A Support for Strategic Choices”, International Institute of Applied Systems Analysis, Laxenburg, Austria, 1991

13. Haldene, J. B. S., “The Mathematical Theory of Natural and Artifitial Selection”, Transaction, Cambridge Philosophical Society, 23, 19-45, 1945.

14. Modis, T. “Predictions”, Simon&Schuster Eds, New York, p177, 1992.

15. Kondratiev, N. D. “The Long waves in Economic Life”. The Review of Economic Statistics, 17, 105-115, 1935.

16. Paquet, A. “Les Fluctuations Economiques”. Analyse des Theories, Editions Doniat Paris, 1954.

17. Vargas, J. I. “Minas e as Utopias: a perspectiva científica” in: Andrés, Aparecida (org.). Colloquium on Utopias: Sentidos, Minas, Margens. Belo Horizonte: Ed. UFMG, 1993.

18. Cidades Históricas Brasileiras - Tradição Musical de São João del-Rei http://www.cidadeshistoricas.art.br/hac/artmus_03_p.htm

19. Erário Régio S. M. F. de Francisco A. Rabelo 1768, Tarquínio J. B. Oliveira Ed., Escola de Administração Fazendária, Brasília, 1976.

20. Trifonov, D. N. , Trifonov, “Como fueran Descobiertos los Elementos Químicos”, MIR Ed., Moscow, 1984

Text for Discussion:

MORE AND JOBS WITH THE SAME CAPITAL OR HOW TO INCREASE CAPITAL.PRODUCTIVITY

Carlos Feu Alvim
feu@ecen.com

1 – Introduction

Brazil presents low capital productivity relative to its development level, as we have shown in previous articles.

Efforts aiming at increasing productivity in Brazil have almost always been focused on the abundant input (labor) instead of on the scarce one (capital). It is not rare as well to relate productivity to physical production and not to aggregated value. Now if we take the example of an industry (capital intensive) such as the steel industry, it makes no sense at all to evaluate the productivity in tons of steel per laborer if it is not taken into account the commercial value of the product and the efficiency in using the capital.

A development policy for Brazil should emphasize the productivity of existing capital goods and those to be installed. In our evaluation, this could significantly contribute to overcome the limitations to growth that Brazil has been facing in the last 25 years. In fact, each percent point gained in the global capital productivity means – for the same capital stock – the same percent growth in the GDP.

Therefore the challenge is to generate more product and more jobs with the same capital. Offering recommendations for such a policy –like those adopted in other countries such as England, Australia, New Zealand and Germany – is the objective of the present paper.

In the present article we will: (1) recall the macroeconomic diagnosis already made, (2) comment on the sectorial (microeconomic) diagnosis of the Brazilian industries carried out by the McKinsey Consulting company that has already performed other comparative studies at the international level, (3) identify the needs regarding understanding the subject and (4) suggest some macro- and microeconomic measures aiming at increasing the capital productivity.

2 - Recalling the Macro Diagnosis

From 1999 on Brazil needs twice the capital that was necessary in 1970 to generate one unit of product and almost three times that of 1950. This larger capital quantity for generating one product unit, together with investment decrease, has been halting our development. A developing country where capital is the scarce factor should have a larger capital productivity than that of the developed countries. This productivity would gradually decrease along its normal growth process.

However when this productivity swiftly approaches the level of the developed countries without the corresponding income of those countries (as is the case of Brazil) we are facing a strangulation point in the normal growth process of the country.

Concern regarding the capital productivity decrease can be identified in Brazilian studies where the capital/product ratio (K/Y) appears as an end or a means for determining growth scenarios. Besides our previously mentioned papers, we could mention papers published by the Instituto Nacional de Pesquisa Aplicada – IPEA (National Institute of Applied Research), such as Morandi, Zygielszyper, Reis (2000), Bacha and Bonelli (2001) and by the Banco Nacional de Desenvolvimento – BNDES (National Development Bank), Carvalho (1996). We could also mention papers that examined the problem in Latin America, Hofman(1992) and Hofman (1997).

In Aumara Feu's thesis (2003) about capital productivity we can distinguish three factors that, from the macroeconomic point of view, have contributed to reducing capital productivity:

a) Content effect – increase of capital stock by product unit in the sectors;
b) Structure effect- reallocation of production to sectors that are more capital intensive;
c) Price effect– price increase of capital goods relative to the price of other products.

For the purpose of the present paper it is important to distinguish the contribution of each effect. It is also interesting to consider our productivity at international prices in order to evaluate our competition relative to other countries. In Figure 1 it is shown the evolution of the capital/product ratio (a) estimated in current values (products and investments corrected by the GDP deflator), (b) at constant prices and (3) at international prices.

Comparing the evolution in constant values and in current values one can evaluate the price effect. The capital productivity between 1970 and 2000 has dropped 455 points in current values. Out of this decrease, ten points can be ascribed to the price factor. One can see in Figure 1 that price had a preponderant role in the second half of the eighties.

A distinction between the content and structure effects was established in the mentioned thesis. For the developed (OECD) countries it was possible to evaluate the two effects along two and a half decades (1970 –1994) since sectorial investment data was available. For Brazil it was only possible to analyze (in the mentioned thesis) the 1985-1994 period using IBGE's sectorial structure and the sectorial capital product ratios calculated for OECD countries. From this evaluation it resulted that ¾ of the productivity decrease in that period (at constant prices) can be ascribed to the structure effect[1]. That is, Brazil has changed its product distribution among the several sectors by privileging the capital intensive ones.

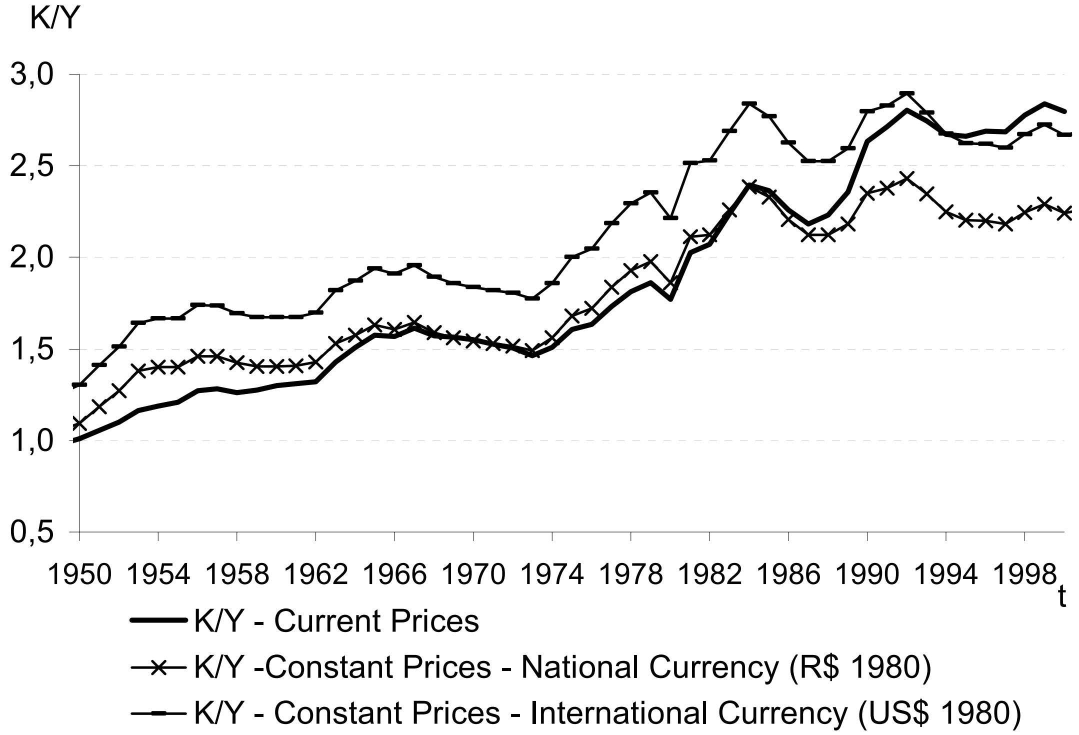


Figure 1: K/Y ratios in Brazil, with current price and constant price investment in national and international currency. Source: Aumara Feu's thesis (2002)

It should be recalled in the present recapitulation the results obtained for the capital/product ratio in what concerns capital stock of the following items: machines and equipment, others, residential civil construction and non-residential civil construction.

Contrary to what a hasty analysis could conclude, the ratio between the stock of machines and equipment and the total product has not changed along time. It reached a maximum in 1980 and has been decreasing since then. Incidentally, in absolute value, the stock of

[1] It was carried out an analysis of the intensity effect evolution in two sectors in Brazil, for which investment data was available. The conclusion was that the intensity was underestimated, at least for these sectors.

machines and equipment at the beginning of the eighties has decreased in the middle of the nineties and was resumed at the beginning of 2000. That is, the real value of our stock of machines and equipment is now almost equal to that of 1980.

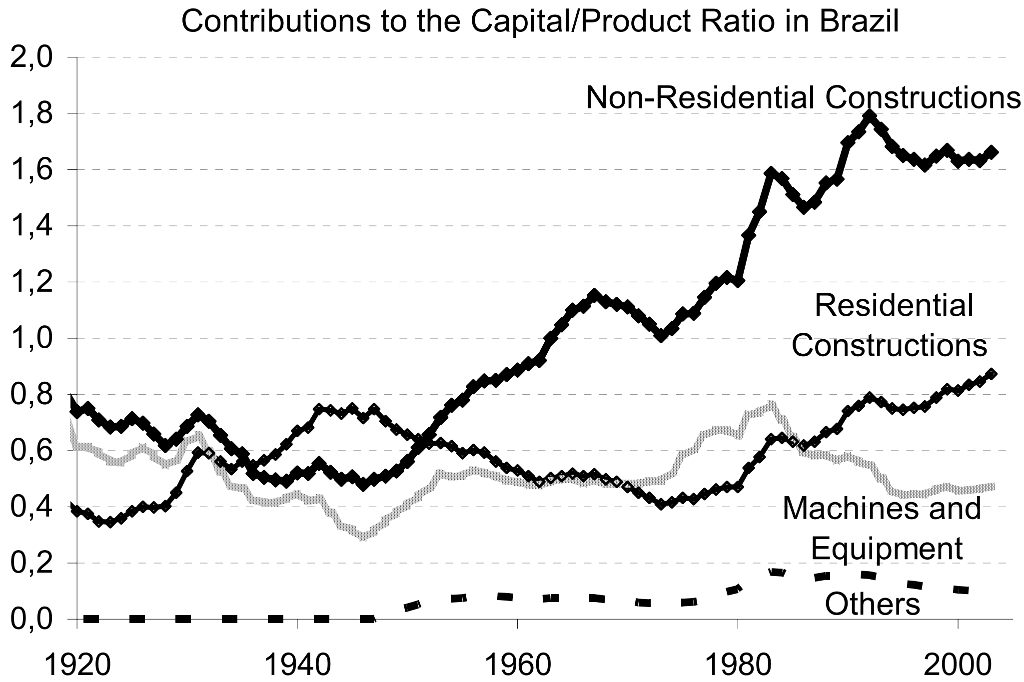


Figure 2: Contribution to the Capital / Product ratio from each type of good. Source: e&e No 44.

Therefore, we can infer from Figure 2 that the non-residential constructions segment[2] has the largest responsibility regarding capital productivity decrease (increase of the capital/product ratio).

We can conclude in this recapitulation that:

- Capital productivity in Brazil is low, taking into account its development level;
- The price of capital goods is responsible for about 20% of capital productivity decrease (10% in 45%);
- There are indications that part of the productivity decrease was due to the fact that productivity was shifted to capital intensive factors;

[2] One of the factors that has contributed was the fast urbanization process in Brazil and the growth of large agglomerations. Between 1940 and 2000, the urbanization rate in Brazil grew from 31% to 81%. The urban infrastructure can be in part responsible for the capital productivity reduction.

- The main responsibility regarding capital productivity decrease falls on the increase of non residential construction goods relative to the GDP.

3 – Micro Diagnosis

There are studies comparing the same productive sectors at the microeconomic level in different countries in order to make a diagnosis of the real situation of the factor's productivity in production units.

These studies point out management techniques so that the resources would be allocated in a productive and efficient form. The consulting company McKinsey has carried out one of its comparative studies for Brazil. The results for some sectors are shown in Table 1.

Total Productivity in the Studied Industries (USA=100)

Sector	Total Productivity	Labor Productivity	Capital Productivity	Capital share(2)
Steel	77	68	87	50
Telecommunications	64	45	75	69
Airlines	61	47	79	50
Car Industries (1)	52	31	170	30

Source: MCKinsey (1) only passenger cars, (2) estimated using Cobb-Douglas function with capital share estimated for a set of studied countries. [3]

The results of the studies show a capital productivity 20% lower than that of the USA for three of the four industries presented and higher than that of that country in the car industry.

In order to compare the industrial level diagnosis with the macroeconomic one it is necessary a compatibility of parameters between both type of studies which naturally does not exist[4]. However, as the sectorial analysis uses homogeneous criteria for the different

[3] The total productivity here is the geometrically weighted average of productivity (capital and labor) relative to those of the USA. It is not the so called "total productivity of factors" commonly associated with technology.

[4] The study points out an economical productivity as a whole that is 60% higher than that of the USA, what contradicts the conclusion of our paper and those of other authors who studied the subject. Adopting depreciation curves similar to those used for accounting purposes (shorter amortization period) would lead to such results.

analyzed countries, it is possible to use the results of the sectorial studies in order to favor a macro objective that would consist in increasing the capital productivity of the country.

The McKinsey study – as well as others that might exist in this area – could and should be used to reach the global objective. From the preliminary analysis of its executive summary (the sectorial studies are also available at the Internet) one could arrive at the (hasty) conclusion that there is not much to be done in the capital productivity area since the difference between our productivity and that of the United States is not higher than 25% in none of the sectors[5]. There are much higher gains to be obtained in the labor productivity. However, we would be forgetting that at the same development level in which we are now, the capital productive of the countries that now belong to the first world was much higher than it is now.

Let's take, for example, the automotive sector where the capital productivity was – as was expected in a developing country – 70% higher than the American one (in 1994). Probably, not by chance, the labor productivity in this sector (pointed out in the study) was only 31% of the American corresponding value.

A more rational criterion to increase the productivity would be to increase the total productivity (relative to that of the USA). However, when this is done, one should pay attention to the remuneration division between capital and labor[6]. In the McKinsey study, due to the comparative objective, the remuneration division is based on the average value of the countries under study, namely 30% for the capital and 70% for the labor in the case of the car industry. But this remuneration division is valid for the analyzed countries while it is certainly not valid for Brazil, where the labor remuneration is generally lower. That is, even when it is intended to increase the total productivity relative to that of the USA, one may not be taking into account that in Brazil the capital weight is greater than in the USA. Perhaps it would be more interesting to maintain the existing comparative advantage instead of increasing the labor productivity in detriment of that of the capital.

It should be emphasized that the McKinsey study does not limit itself to suggest measures for one or other specific sector but it outlines a general framework for the different sectors. The study tries to quantify

[5] In telecommunication, where it is 75% relative to that of the USA.

[6] The capital remuneration in developing countries like Brazil is expected to be higher than that of central countries. This remuneration would imply a higher weight for the capital productivity when the total productivity is calculated.

the job losses and the investment that would be necessary for the surplus labor to be absorbed by the resulting growth and, besides, to increase the formal jobs. According to the study, with 5% growth per year there would not be a decrease in informal occupation due to the increase of the projected labor productivity in Brazil. It would be necessary to increase the present investment rate from 19% to 26% of the GDP and grow 8.5% per year during ten years in order to decrease its informal jobs from 50% to 40%. Furthermore, the country would have to increase its exports in about 12% annually in order to face the necessary imports to reformulate and modernize its productive park.

That is, the total productivity increase aiming at reaching the labor productivity of the developed countries makes macroeconomic sense only in an accelerated economic growth framework. Without that growth, unemployment and informality would be aggravated.

4 – It is Necessary to Deepen the Diagnosis

Initially it would be necessary to deepen the diagnosis concerning the causes of inefficiency in the use of capital goods stock. A wrong diagnosis could lead to measures that would aggravate the problem instead of alleviating it. For example, Brazil has presented in the last years a low investment rate (gross formation of fixed capital). The credit offer, with subsidized interests, or even the Government's guarantee, through administered prices, regarding investments remuneration may aggravate the problem of low capital productivity[7].

As we have pointed out, the capital productivity decrease (at constant prices) may be caused both by directing production to techniques that are more capital intensive and by reallocating capital to sectors that are more intensive in using this factor. In the real economy, where relative prices vary, capital goods prices is the other important factor.

Therefore, knowing the behavior of the variables that affect the capital productivity at the aggregated and non-aggregated levels might indicate measures at the macroeconomic and sectorial level to improve the performance of the country regarding these items.

---

[7] The fact that elections will soon be held (the present month is July 2004) has prevented (or postponed) increasing contributions of enterprises to Social Security. Government authorities have promised that there would be a compensation by tax reduction in other areas. According to what was later revealed, these measures were intended to reduce investment costs (capital) that would compensate a cost imposed on labor.

Encouragement should be provided to studies concerning private and government planning aiming at orienting investments to sectors or techniques that are less intensive in using that factor and generating more significant growth scenario for the future.

The preliminary items of the policy to be adopted in order to overcome the present situation would be removing the obstacle in the productive system, specially the process factors, and concern regarding the quality of investments and not only its quantity.

Measures for implementing the capital productivity

Increasing the capital productivity of a continental country like Brazil is not an elementary task,. mainly when one does not have a definitive diagnosis. In what follows, we list some measures, both global and local, that could, in a preliminarily analysis, contribute to increase the capital productivity:

1. **Larger use of the productive park**: an important measure in the reduction of the capital/productivity ratio is to make possible the more intensive use of the existing production goods, amplifying the working days and hours. This will have as consequence an increase in work demand and job offer using the same productive park. To materialize this objective would require, for example, measures that would favor, without any loss to the laborer, the definitive or temporary elimination of labor limitations to the larger use of the productive park.

2. **Give priority to productive sectors that are less capital intensive:** an analysis of the capital productivity could be a tool for granting favored credits[8]. Evidently, incentives to investment should not result in stimulating inefficiency regarding capital use and consequently capital/product ratio decrease.

3. **Motivate capital productivity sector-wise:** one sector can improve its productivity by better using the production means. Like it is made in quality programs, measures in the management area could increase, at the same time, both capital and labor productivities.

---

8 It should be noted that capital productivity evaluation is not intuitive. For example, public service is capital intensive since large investments in civil works per public servant are necessary and the servant's salary is the element used for calculating the contribution of public service to the GDP. The same is true in what concerns tourism, that requires large investment per product.

4. **Increase in a qualitative way the aggregated value in each sector:** since the capital productivity corresponds to the product/capital ratio, it can be increased by reducing the denominator or increasing the numerator. The numerator could be increased if the country would try to participate in more advanced stages of production and not in the intermediate products (predominantly, our exports line). Other forms for valorizing our product, such as improving its quality, its sophistication level and incorporating new technologies should also be pursued. One should not forget the commercial aspects such as establishing trade marks that constitute a significant part of the aggregated value.[9]

5. **Coherent taxation aiming at increasing capital productivity:** in a phase where it is necessary to increase the production capacity, it is preferable to tax consuming goods instead of production ones. Investment stimulation must be selective to prevent suppression of jobs, which cannot be economically justified without subside to capital.

6. **Promote development in medium and small cities instead of large urban areas**: in the analysis it was concluded that the large capital/productivity ratio (decrease of the capital productivity) is connected with non-residential constructions that characterize the large human concentrations. Encouraging urban dilution means to reduce the need to invest in urban structure by generated product.

7. **Reduction of costs associated with the Government:** It is necessary to reduce the investment costs associated with the bureaucratic, regulatory and administrative processes. Reduce the duration of works that, due to bad planning or multiplicity, permits the capital to remain idle for several years, increasing the capital/product ratio and charging investment costs. Mainly in the public sector, reduce costs through the rationalization and moralization of the public bidding process.

Conclusions

We started with the verification that the capital productivity decrease is one of the reasons of the stagnation of the growth per capita in Brazil. In the present article, the idea is to draw up a schedule using a diagnosis about the capital productivity decrease in Brazil and indicate

[9] In spite of the fact that the footwear industry in Brazil is competitive, it has no important trade marks. Brazilian products are frequently sold abroad using foreign trade marks that hides their origin.

possible actions aiming at increasing the capital productivity and consequently increase growth in the country.

Identifying the measures is neither exhausting nor definitive. It would not be surprising that a deeper analysis would indicate that some of them are inefficient or even disadvantageous.

If the subject is relevant, and we believe so, it should be considered and analyzed by society, including class, governmental and legal organizations. It would be desirable that this process would not retard actions whenever there is a reasonable consensus about the subject.

It should be recalled that some actions are already under way and in some of them the governmental contribution may be just not to upset it. In the previous issue of our periodical we have mentioned some promising facts such as night flights with promotional prices that favor the larger use of the capital invested in airplanes and airports and the fact that the Ford company uses its production capacity during 24 hours of the day in some of its units. Recently the subway company in Rio de Janeiro has offered cheaper tickets for early passengers. Shopping centers have also realized that in order to compensate investments it was necessary to be open during more hours. On the other hand, even though for reasons different from those pointed out, it is already observed a trend regarding the transfer of producing centers to smaller urban centers.

In other points it seems that we are going in the direction opposite to the desired one: particularly the taxing policy and even (in some points) the labor policy, namely favoring capital in detriment of labor. Points of concerns are the additional costs imposed on the productive investments due to legislation, regulation and bureaucratic excesses. The lack of planning, the economic uncertainties and the excessive interest rates also continue to delay and make investments more costly, reducing the capital productivity

REFERENCES:

BACHA, Edmar L. e Regis Bonnelli, ”Crescimento e Produtividade no Brasil: o que nos diz o Registro de Longo Prazo.” Rio de Janeiro: Seminários da Diretoria de Estudos Macroeconômicos do IPEA 52, 2001.

CARVALHO, José Carlos, “Estimativas do Produto Potencial, Relação Capital/Produto e Depreciação do Estoque de Capital.” Rio de Janeiro: Textos para Discussão, Área de Planejamento do Departamento Econômico do BNDES 44, 1996.

FEU ALVIM, Carlos. “Capital Productivity: A further Limitation for the Brazilian Growth” Economy & Energy, 44 (June-July), 2004.

FEU, Aumara. Produtividade do Capital no Brasil de 1950 a 2002. 151 f. Tese (Doutorado em Economia) - Universidade de Brasília, Brasília, 2003.

______. “ Evaluation of Capital Productivity in Brazil in the XX Century.” Economy and Energy. 43 (May-June). 2004

HOFMAN, André. Capital accumulation in Latin America: a six country comparison for 1950-1989. Review of Income and Wealth, v. 38, n. 4, p. 365-401, Dez. 1992.

______. The economic development of Latin America in the twentieth century. Northampton, MA: Edward Elgar, 2000.

MORANDI, Lucilene; ZYGIELSZYPER, Nora; REIS, Eustáquio. Tendências da Relação Capital/Produto na Economia Brasileira. Rio de Janeiro: IPEA, oct. 2000. (Boletim Conjuntural do IPEA n. 51)

The Periodical

Economia e Energia – *e&e* – *Economy and Energy*

e&e is a bimonthly and bilingual periodical edited since 1997 and published on the INTERNET. Its objective is to disseminate articles and reports and promote discussions on matters connected with its title. For its maintenance the periodical has the support of its staff members and, in a non-continuos basis, of public and private institutions. Whenever available, this external support is indicated in the publication. Its chief-editor is Carlos Feu Alvim [feu@ecen.com].

The Non-Governmental Organization

Economy and Energy - *e&e* - NGO

Economy and Energy – NGO is a nonprofit organization that was established for supporting the periodical with the same name and for promoting studies related with economy and energy. In the case of studies for governmental or private institutions it hires individual consultants or consulting companies for the job. It can also celebrate agreements with public and private institutions. Its superintendent is Frida Eidelman [frida@ecen.com].

Support:

Ministério da Ciência e Tecnologia

BRASIL UM PAÍS DE TODOS
GOVERNO FEDERAL

anp Agência Nacional do Petróleo

ELETRONUCLEAR
ELETROBRÁS TERMONUCLEAR S.A.

Eletrobrás
Centrais Elétricas Brasileiras S.A.

Ministério de Minas e Energia

BRASIL UM PAÍS DE TODOS