

*The Mathematics of History:
Alexandre Deulofeu's unknown theory*

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Abstract

The paper discusses two topics. The first is to submit the work of Alexandre Deulofeu who drafted a theory about the evolution of cultures and civilizations. The second goal is to argue that the theory of Deulofeu, far from being one more cyclic theory, has a scientific basis that fits well with the modern approaches of complexity theory and the emerging systems. The aim is not to defend the overall validity of the theory but rather assert the validity of its approach. The paper pose some questions that historians seem to avoid, such as: are there emerging laws in history?

Contents

Part I

1. Introduction	3
2. Who was Alexandre Deulofeu	5
3. A summary of the Mathematics of History	6
4. Alexandre Deulofeu's predictions	15

Part II

1. Subject layout	18
2. Finding common concepts	19
3. The dynamics of the Mathematics of History	24
4. On the onset of history	26
5. Criticism on cyclic theories	27
6. Cyclic evolution and material progress	29
7. The breakdown of complex societies and the Mathematics of History	31
8. Could historical simulations be made?	33
9. Open topics	34
10. Conclusions	35
References	37

Figures

Figure 1: Graphic of the Evolutionary Cycle	8
Figure 2: Chart of Process Imperial	15

Tables

Table 1: Imperial Processes	16
Table 2: The Three Cycles Of Civilizations	17

Part I

1. Introduction

This article has a double purpose. In the first place, to introduce the work of Catalan historian Alexandre Deulofeu (1903-1978) to the international scholarly world. Deulofeu developed a theory on the evolution of civilizations, which he called *Mathematics of History*. According to this, the whole of civilizations follow the same development phases before they disappear. And besides, this happens following the same surprising and consistent time patterns. The second purpose is to carry out an interpretation of his work within the framework of present-day science.

Deulofeu used to write in Catalan, and only a few of his books were translated into Spanish. At present it is almost impossible to find any of his works in the bookshops. His work has been forgotten even in his own country. There are several explanations for this. On the one hand, he was an unorthodox who always acted outside the scholarly circles. On the other, his propositions are distressing and not easy to accept, since they seem to limit human freedom. In his time, no publisher would publish his work, which compelled him to create his own publishing house in order to be able to publish his books. Luckily, thanks to his chemist's shop he was in a position to support the publication of his books.

Even if they have been about for a long time, the cyclic theories of history have never enjoyed a good reputation. When we hear about a cyclic theory we immediately think of a repetition of happenings, (in short predictions in the style of Nostradamus), of a number of commonplaces and preconceptions which must be clearly banished. In this article we shall try to demonstrate that Deulofeu's theory is based on sound principles and has a real empiric foundation. As a consequence, it can be greatly useful in the framework of present-day science. This, of course, does not mean that it should not be criticised, amended and updated.

The first part will be dedicated to make a brief résumé of the *Mathematics of History*, following as much as possible the language used by Deulofeu. In this part there will also be, under a separate section, the main predictions made by Deulofeu himself concerning the future of present-day societies. It must be pointed out that these predictions were made in the fifties and sixties of the last century, which, in our opinion, makes them especially meritorious.

In the second part we shall engage in a number of matters related to the *Mathematics of History* from our own personal viewpoint. The main purpose will be to show how useful the approach can be. After an introduction to establish the framework within which we shall develop our discussion, we shall try to point out some of the ideas which may help to establish comparisons among different societies in the course of time.

The difference among the technologies used in each time period often makes it difficult to correlate such societies. Here we shall submit a proposition in order to overcome this difficulty. After that, based on the concepts put forward in the previous section, we shall briefly re-write the social process described by Deulofeu using such concepts. Following this we shall debate the moment when historical cycles begin. Thereafter we shall analyse the criticism made to the cycles theories trying to demonstrate that they are not applicable in the case of the Mathematics of History. Another important item will be to bring together cyclic evolution with material progress. We will debate that they are independent processes which must not be mixed up. We shall use the idea of complex systems to justify this. Then we shall re-examine some authors who have approached the subject of the evolution of societies and we shall see to which extent they can be merged in Deulofeu's theory to complete it or to improve it. We shall also ask ourselves whether in the future it will be possible to make historic simulations. Finally we shall deal with some of the matters which, in our opinion, have remained more open in Deulofeu's theory. The most important one will take us back to the beginning: *Will mankind be able to avoid the laws which seem to dominate its future?*

The second part in this paper is an attempt to demonstrate that Deulofeu's work can very well round off some of the contributions made by other authors in the field of social sciences. Many have shown their concern that social sciences and history may overcome their old limitations and become real sciences. In this sense, this article is indebted to all of them even if they are not explicitly mentioned. For this reason we wish to acknowledge our debt towards all of them. Within the framework of history, to the works of Fernand Braudel, William McNeill, David Christian, Fred Spier, Ward-Perkins. In historical sociology, very especially to Charles Tilly, Norbert Elias, and Michael Mann. For economics, to Piero Sraffa and Nicholas Georgescu-Roegen. Among anthropologists, to Joseph Tainter and Norman Yoffe. In the always difficult and stimulating field of divulgation of science, to Steven Johnson and Ricard Solé. And finally, in

the field of biology and the theory of complexity, to Stuart Kauffman and Ludwig Bertalanffy, and to Daniel Dennet for philosophy.

To include the language and ideas of these authors to Deulofeu's discourse may help to consider his work with an increased interest and to re-discover its great value. In short, it may be a means of enriching both parts.

2. Who was Alexandre Deulofeu

Alexandre Deulofeu was a self-taught historian, born in 1903 in L'Armentera, a small village near Figueres, province of Girona. As a child his family moved to Figueres, where they carried on their professional and research activities. He studied two careers, chemistry and pharmacy. After his degree, he taught in the secondary school at Figueres. In the years thirty of the last century he was actively involved in the political life of this town, and after the civil war started he became acting mayor. As such he was able to avoid some fights, pillages and pursuits in his town. At the end of the Spanish civil war he went into exile to France until 1947. There he was able to complete his research on history on which he had been working since the years thirty. During his exile he carried out different jobs: teacher (of different subjects), violin and saxophone player (in several music groups for entertainment and classical), experimental farmer (creating cultivations without any soil with liquid solutions he invented), factory worker, mason, writer, poet, etc. He was a versatile man, completely self-taught as far as history was concerned. He died in 1978, leaving unfinished an enlarged version of his *Mathematics of History*.

His first book, where we can find already the principles of what will later be his theory of history, was written in 1934. During his exile he developed his theory of the mathematics of history, but it was only in 1951 when he first published a résumé of his theory in Spanish. In the bibliography at the end of this paper can be found the dates in which his works were published. Originally his works were written in Catalan, but because of the repression of the other languages of the State in Spain, they could finally be published in Catalan in the sixties of the last century, when the repression of Franco's regime started to decline.

In the sixties he had to undertake himself the publication of his works, as no publisher wanted to carry on publishing his works. Within the scholarly world he suffered a total marginalization, even if in private some of his peers admitted their respect for his work. The implications of his theory are not pleasant and are difficult to accept because they apparently limit human freedom and restrict their evolution as exposed by the *mathematics of history*.

Unfortunately, social sciences have difficulty in separating the analysis of societies from their legitimate hope to attain a better society.

Deulofeu was a great observer of historical events. He was able to see beyond and above individual events to single out the processes which, in his

opinion, motivate the peoples' trends. Many scholars had already made the attempt, but none, up to that moment, had been able to formulate a general enough theory which could be applied to all civilizations. Deulofeu's theory is a descriptive one, but it has a consistent script and an inner logic which are almost indisputable. The first question to emerge when one reads it is obvious: *can't mankind escape from this law?* This matter will be tackled in the second part.

Deulofeu worked out the bulk of his theory in the forties of the last century, and he never showed any interest in finding out the origin of this law. For him, after its discovery, it was so indisputable that he naïvely thought that his findings would be acknowledged. In those same years science was setting the bases for an in-depth renewal of biology, cybernetics, systems dynamics, etc., which would open the door to the theory of emerging systems and complexity. This allows us today to try and find the bases of Deulofeu's theory in this new field of science. All of this will also be tackled in the second part.

3. A summary of the Mathematics of History.

The social process of the Mathematics of History.

The Mathematics of History was a far-reaching project which was to be developed in ten volumes. In his life he only could publish eight of them. In 2005 his grandchild, Juli Gutiérrez Deulofeu, while working on his grand-father's papers, adapted the last two volumes into one, which completes the original project. Besides the books which make up Deulofeu's work, he published several books which summarize the contents of the mathematics of history. In one of them could be found a blueprint in short of the law of the Mathematics of History in the following items which we reproduce here:

1. All the peoples go through periods of great demographic division, alternating with periods of great unification or imperialistic periods.
2. The periods of great division last six centuries and a half. The periods of great unification last ten centuries and a half. Therefore, the evolutionary cycle comprises seventeen centuries.
3. During this evolutionary process, the peoples go through perfectly defined phases. At the end of the cycle, they are in the same position as at the beginning.
4. The evolutionary cycle comprises all the types of human activity, so, besides considering a political cycle, we must also consider a social, arts, philosophical and scientific cycle.
5. All the peoples follow the same evolution, but this gets ahead or lags behind depending on the geographic situation of each country.
6. Not all the peoples show the same creative force. In each cycle there is an area of maximum creative intensity and this area moves from

one cycle to the next following the steps of the overall process. In Europe, this goes in the Mediterranean from East to West and then from the Iberian Peninsula to Gaul, it follows to the British Isles, then through the Germanic peoples and finally arrives to the Northern and Slavonic peoples.

7. The imperialistic nuclei which give rise to periods of great political unification follow perfect biological processes, identical to each other, which last for five to six centuries.
8. The transformation of the socio-political regimes does not take place following a constant upward or downward trend, but by means of forward and backward steps, each being alternatively more intense than the others. This results in a broken line, which is an advancement in a given direction. It is what is called *Law of two steps forward and one backwards*. (Deulofeu, 1967)

We shall now describe the social process as is described by Deulofeu in the first volume of the Mathematics of History. (Deulofeu, 1956, 1970)

Graphic of the Evolutionary Cycle

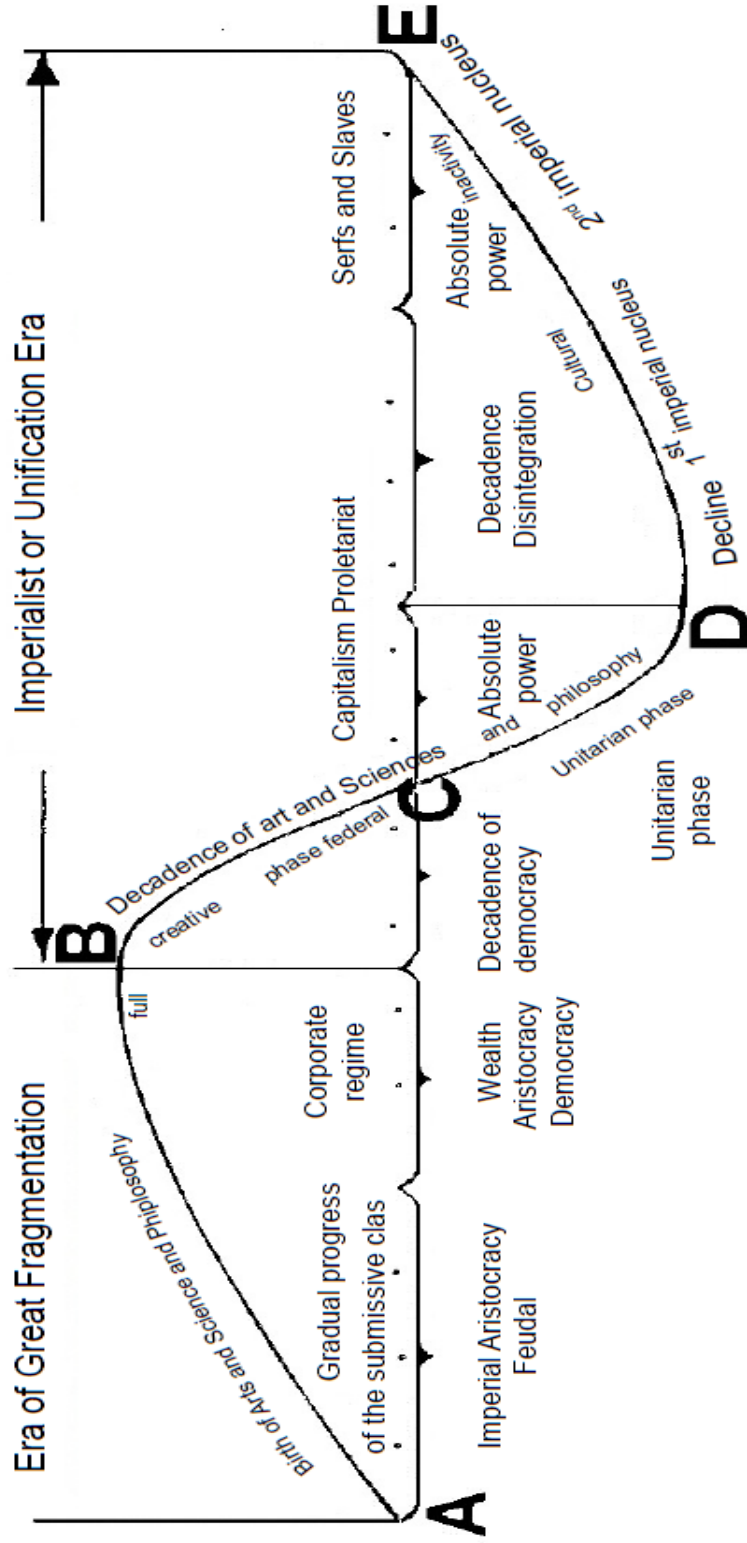


Figure 1 (Deulofeu, 1956, 152)

The priestly aristocracy.

At the time when societies start their social process, their structure is simple, it is based on the family and the relationship among family groups. There is not a well-marked division of work. Every family faces its own needs. They are farming economies with a very simple basis. There is a family head and the families living in the same area have a council which has in turn a head. Therefore the organization is hierarchical.

The class on top of the social ladder is the aristocracy of priests. It is made up by the family heads which at the same time have the priestly functions. It is a domestic religion, every family has its own cult, based on the ancestors worship.

The units which make up this first human group are difficult to tell apart from each other. They may be classified in three groups: the serfs and the slaves, or submitted classes, which carry out domestic chores, the elements constituting the family proper, and the house head.

According to Deulofeu, when the process starts, this primary society changes. There is a *wish to improve*, an increased activity, and a tentative industrialization begins. The brothers, sons and grandchildren of the head of the house take part more and more in the family activities. The increased work intensity and the starting industrialization now make them necessary. The family head is no longer able to manage on his own a body which is becoming more and more complex. The other members of the family become essential in their specialized work, and this fact gives origin to a social transformation.

The increase of the economic activity implies a growth of trade and an increase of the complexity of relations. All the heads and foremen within the scale structure feel overflowed in their positions. The council members are no longer passive elements as before, on the contrary now they will discuss and criticize. A social revolution floods all the cities, and with it the absolute power of the king, of the tribal heads, of the *phratries* and of the family heads collapses. At the same time, the right of primogeniture, which used to perpetuate the great families, starts to disappear.

The *priests aristocracy* starts its decline. The superimposed powers start to disappear, and these changes mean a great step forward towards the equality with the ruling class. In the end, by means of several transformations, a fair sharing out among brothers is reached.

At this point there is a change in the political structure of society. With the sharing out of possessions among the brothers, the number of town representatives also increases. There is a breaking up of the power structure of the cities which becomes weaker. However the process is very slow. Rivalry among the members of the ruling classes causes them to make concessions to the lower classes. Little by little some serfs become owners and keep the harvest in exchange for an allowance.

Together with this process the creation of riches increases and as a result little by little a new social class appears, which Deulofeu calls the *aristocracy of wealth*. The land ownership is no longer the only wealth source as a consequence of the increased economic and trade activities and of the spreading use of money. The new aristocracy springs mainly from the serfs which have reached freedom. As a result of this, communication systems, roads, mail services, defence bodies and all sorts of institutions are organized, which become more and more complex as the time goes.

At this point the artistic sensibility wakes up and the architectural styles, together with painting, sculpture, etc. begin to appear. The renovation process starts an upward path which will lead the peoples to the summit of their creative power.

The aristocracy of wealth.

The new aristocracy does not resign itself only to the material power and starts a struggle to attain also political power. This change does not take place overnight, but through a long process of victory and defeat. The new city managers are people used to work, which have attained their wealth through their own effort. They appreciate not only material riches, but also spiritual wealth. This new aristocracy will encourage art and science in all their multiplicity. Large civil and public buildings are raised, and also large private palaces.

However, the aristocracy of wealth will stay in power for a relatively short period of time. The following generations little by little relinquish the spirit that their parents and grandparents had had and become lazy, while at the same time they lose the support from the subordinated classes. At this time a new political change takes place, which causes the middle class, organized in associations and guilds, to enter in the towns governments. The time for democracy has arrived.

Democracy.

Deulofeu dedicates some pages to expound his idea of democracy. He considers democracy as a regime of total freedom, where freedom exists for the individual, the family, the city, the regions and the peoples. In such a regime individuals can develop all their faculties. Among all the citizens, a multitude of craftsmen appear to work in the arts; philosophy finds and inexhaustible breeding ground of scholars, and so on for all the fields of learning.

But democracy does not aim at keeping social equality, well on the contrary it tends to divide society into rich and poor. The more intelligent, more active and qualified will have a preeminent position. During some time the redistributive mechanisms are maintained. At the beginning the rulers find it logical that the State should avoid the poverty of the lower classes. Later, the solidarity spirit disappears and they find that the provisions which limit their personal enrichment are unfair. Protests begin and there is a will to flout the law. On the other hand, the citizens lacking material resources want to get them whichever way, which encourages some

to sell their vote to avoid the approval of laws which would damage the interests of the rich. Corruption spreads and the concentration of wealth in a few hands brings anarchy and civil war to the cities.

In the cities great corporations appear, while small companies and shops are ruined, and the middle class becomes part of proletariat. In the country, small properties are devoured by the great landowners and disappear, the middle class too from being landowners become labourers. The consequence of this process will be the loss of the cities' independence and the start of an imperial period or of political unification.

Deulofeu calls the period included between the beginning of the evolutionary cycle and the decline of democracy a "time of a *great demographic division*" and assigns to it a length of six and a half centuries, which are shared by the *feudal aristocracy*, four centuries, and the *aristocracy of wealth and democracy*, two and a half centuries. These first centuries are described by Deulofeu as a gestation phase. In this time period everything is created, both in the political aspect and in the social, intellectual, scientific or philosophic aspects. A culture has been created. With the imperial period a new phase starts, with a phase of development, exploitation of ideas and of the great concepts of the creative period. It is the step from culture to civilization.

Constitution of an imperial nucleus¹.

At this time of decline of democracy, cities find themselves immersed in chaos and civil war. Since not all the cities start the civil war at the same time, some of the disputing factions decide to ask for help from one of the neighbouring cities. This will cause the helping city, besides being paid for its help, to find a way of solving its own interior conflicts. The protecting city, which was also on the verge of a civil war, by sending out its army, finds a solution to its problems. In this way it can delay the conflict which would have broken out inside. Other cities which find themselves in the same situation, ask for assistance from other cities. In a large area there will be many cities which will have helped their neighbours. This will start a fight among these cities to reach hegemony. The one which will win will constitute the *imperial nucleus*. Deulofeu points out that at the beginning the domination of the hegemonic city is almost an accepted intervention.

The federal phase.

This notwithstanding, the cities which have fallen under the hegemony of the new imperial nucleus maintain their own interior organization, their own municipal government, even if they have lost the initiative as far as external relations are concerned. This regime of inner freedom will be re-

¹Deulofeu uses the word "empire" with a different meaning from that usually applied by historians. Often, empires are related more to dynasties than to societies, as Deulofeu does. For example, we mention the empire of Alexander the Great, and not the Macedonian empire. This causes that, within the imperial time period corresponding to the mathematics of history, more than one empire may be found following traditional history, one may be related to the first aggressive process and the other to the second aggressive process. The decline and the threefold civil war may sometimes be sensed as two different empires, while, according to Deulofeu they actually belong to the same imperial process.

duced more and more in the first two centuries of the imperial period and the cities in the end will lose their own interior systems, substituted by the law of the imperial city. They lose their own institutions but they step up to the category of citizens of the empire.

As far as the cultural level is concerned, art manifestations dedicated to the whole of population disappear, and they are limited to the halls of the wealthy classes and only for the governing classes. The artists, unable to create original works, limit themselves to repeating the classical style, but burdening their works with an excessive ornamentation.

As far as religion is concerned, after a time of disagreements and philosophical reasoning, freedom of worship is attained. Religions lose some of their old followers, but in exchange they are defended unto death. During the federal phase will start to appear some sort of indifference towards religion, in spite of this however the new empire will still find in religion a support which will keep in check the ignorant masses, but the deep and true beliefs will be forgotten.

First aggressive process.

The new imperial nucleus will not be content with having spread its dominion on a large territory, and to have established a hegemony accepted by a great number of cities. Its craving for power cannot stop. When it finds cities which do not accept its rule, they are subdued by force, and so the first aggressive process starts, which is to be found in all the empires.

During this phase there is an important social transformation. All the activities of the empire are concentrated in the imperial city. People arrive from all over the place and all sorts of trades are developed. On the other hand, the other cities lose their old prosperity and start to decline. The imperial city concentrates all the wealth from the empire and in it magnificent monuments are built, while the masses of labourers from the countryside and from the other cities live crowded in the city in terrible conditions.

The social process towards anarchy, which the imperial city had avoided with its conquests, appears again in catastrophic proportions. The great military undertakings are no longer a source of wealth and an exhaust valve for the social hatreds, and become long lasting wars in distant areas, which are only a source of ruin and misery.

At the same time, an imperial nobility appears which is made up by prebends and official positions, as a consequence of the reduction of the peoples' assemblies, which become slowly limited parliaments, controlled by the powerful. The division in two classes reaches also the imperial nucleus. The catastrophe cannot be avoided. At the same time the powerful contend for their personal power. A threefold civil war is sparked off. In the first place the fight for power among the most powerful members. Secondly, the fight of the people against the powerful, and finally the fight of the cities for their independence.

In this way, with the threefold civil war the *great depression* is attained. At this time the empire, besides being sunk in anarchy, chaos and civil war, it is invaded by the neighbouring imperial nucleus. It looks as if the empire will not survive. But, under the circumstances, one of the factions in the fight imposes its authority, the anarchical masses are controlled, opposing factions are defeated, the peoples, which had declared their independence, are subdued, and all fall under the authority of one single power, a dictator who will impose and lead the destiny of the empire. At this time starts the second aggressive process and finishes the federal phase.

Unitary phase and disintegration.

At the beginning of this period the cities lose their interior freedom and become governed or led by the central power; the peoples which make up the empire lose their personality and their own government. They are split in administrative provinces, controlled by the central government by means of delegates or governors. The laws, the languages and the institutions of the ruled peoples are substituted by the laws, the language and the institutions of the imperial city.

During this phase the empire will carry out a staggering number of conquests, which not only will allow it to recover its old possessions, but it will obtain a great territorial expansion. At this time it aspires to the universal hegemony, but a great military disaster puts an end to its aspirations. In spite of this, it recovers and wins back its domineering position, but its imperialistic claims are reduced. The empire reaches its fullness phase. It is the phase of political hegemony, of predominance, of splendour. This is followed by a conservative phase, where expansionistic whims have disappeared. There is no longer any thought of new conquests, the idea is on the preservation of the great imperial dominions. The empire aspires to be at peace with the neighbouring empires, and, since it is strong and frightful, its wishes are respected. It reaches its most brilliant phase. The emperors only aspire to the wellbeing of their subjects. Order and peace reign from the capital city to the most remote areas. Magnificent constructions are built, roads, canals, and all sorts of civil works. The empire, having reached its fullest, appears in all its magnificence before starting its decline.

But the peace spirit is no longer sufficient for the younger imperial nuclei to keep it. So the older imperial nucleus, lacking the aggressive spirit, will suffer the first defeats, which will start the decline of the empire. At the same time, the independence spirit of the submitted peoples wakes up. The political ideology of the mother country will start to break up, and incompatible political and social ideas will appear. The working class, which believes itself to be essential, considers the other classes as usurpers of its wellbeing. The peoples of the empire, which consider themselves as absolutely better, feel themselves as taken advantage of and oppressed by the hegemonic nucleus. The army no longer feels to be the defender of the citizens and the empire, and feels as a superior class with a right to impose

its own guidelines, to which all the imperial bodies must subordinate themselves. The fall of the solidarity spirit, hatred and envy against anything which moves away from mediocrity, and the incomprehension among the different fields of the empire, will be the cause of the fall of individual values, both moral and intellectual, and of the sense of human dignity, and will open the way to submission and servility.

Finally the disintegration of the empire takes place, but the peoples fall straight away under the domination of the new imperial nucleus, who from the very beginning will act as a true tyrant. It will have all the power in its hands, besides all the riches, and will reduce the ancient citizens of the empire to the condition of serfs or of slaves. The new imperial nucleus will fulfil its evolutionary process and will in turn start its decline and decomposition phase. The weakness of the central government will finally leave the power into the hands of governors and deputy governors of regions and cities, until the complete disintegration of the empire is reached and a regime which is called feudal regime, or superimposed powers, is imposed. At this time we enter in a new age of great demographic division. Then, a new cycle is started. (Deulofeu, 1968).

The last phase of the cycle is that of the imperial or feudal aristocracy, that is that of the governors and deputy governors which have declared their independence from the imperial nucleus. These governors still hold some degree of submission to their immediate superior, and this in turn acknowledges vassalage to that which is above him. Beneath this aristocratic class we find the people, submitted in a regime of servility or slavery, with no material or spiritual power left to it.

From the point of view of culture, we find there is no activity of a spiritual sort. On the one hand we have a corrupt and degenerate aristocracy, with no other concern or aim than to satisfy its material cravings. In the submitted class we find a people which has no possibility of having an education and lives constantly resigned to do manual labour.

The imperial process.

We shall now comment on the imperial process. Even if the cycles, according to Deulofeu, have an exact length of 1700 years, the empires have a length of 550 years. For the empires, however, this time span may diverge slightly from this figure. At the same time, within the empires, the length of the first aggressive process is unstable. Some empires have it very short, while others have it very long. Those which have it longer will have a shorter fullness period, and it will be the opposite for the others. Deulofeu makes a distinction between the continental empires which have their possessions on the same continent and those which have maritime colonies. These, when the decline phase begins, the first thing they lose are the colonies. On the contrary, the continental empires hold their possessions to the very last.

Figure 2. (Deulofeu, 1956,152)

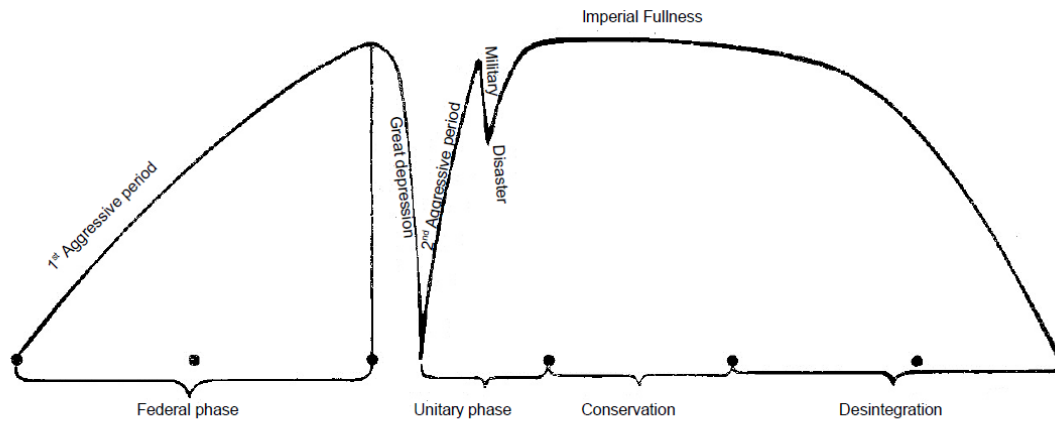


Chart of an Imperial Process

The creative process

It is interesting to point out that the historic cycles within Eurasia move from East to West, with a slight time shift. The law is not carried out at the same time in the different places on earth. According to Deulofeu, the fact that not all the peoples suffer the social evolution at the same time, causes History to seem so chaotic. It is interesting to point out the coincidence with what writes Jared Diamond in his known book *Guns, germs and steel*. In this Diamond shows that agriculture moved within Eurasia from East to West.

Another cause which makes difficult the visibility of the law of History, according to Deulofeu, is the fact that the creative intensity is not the same for all the peoples and for every cycle. Within each culture the creative centre moves also in such a way that the second cycle is not in the same position as the first one. Cultures develop along three cycles of 1700 years, after which they disappear.

4. The predictions of Alexandre Deulofeu.

Deulofeu's work was an ambitious project within the field of social sciences and his great contribution was his ability to observe and to identify patterns within the great spider web of historical facts. His *field work* was in a library and that allowed him to make up a theory to explain not only *after the facts*, because facts had already become history, but he had the audacity to make general forecasts on the countries' future. This activity is very risky and impairs any theory. Even so, Deulofeu did not shun it. From the time his predictions were made in the forties of the last century, it has been verified that his predictions were not way off the target. His predictions are not related to saying that on such day such a thing will happen; they are rather general affirmations on the evolution of empires.

To put an example, when in 1951 Deulofeu published his first summary of the Mathematics of History, he stated that the U.S.S.R. was a decadent empire which had already lost the aggressiveness of young empires and

that it would reach the end about the year 2000. He made this affirmation considering the fact that, according to his estimation, the Muscovy empire had been constituted about the year 1450. Therefore, if we add 550 years, which is the medium length of empires, the result is the expected date of disintegration of the Russian empire around the year 2000. It must be pointed out that this affirmation was made in the fifties, when the U.S.S.R. appeared to be a great power in the eyes of international observers.

Table 1: Imperial Processes (Deulofeu, 1970, 150)

Empires	First Aggressive Process	Depression	Second Aggressive Process	Decay and desintegration	Total
Persian	835-733	525-521	521-490	490-331	504
Cartaginian	650-264	264-237	237-202	202-146	504
Macedonian	700-500	500-423	423-323	323-146	554
Roman	270-129	129-58d	58-160	160-305	575
Visigoth	150a-300d	300-401	401-507	507-713	863
French	250-561	561-626	626-815	815-843	593
Bizantine	500-578	578-717	717-1018	1018-1081	581
Teutonic	800-911	911-936	936-1056	1056-1300	500
Viking	850-1050	1050-1150	1150-1350	1350-1400	550
Danish	900-1103	1103-1150	1150-1227	1227-1475	575
Polish	1025-1227	1227-1306	1306-1572	1572-1609	584
Lithuanian	1000-1260	1260-1316	1316-1380	138-1500	500
Teutonic order	1000-1410	1410-1422	1422-1454	1454-1525	525
Muscovite	1450-1580	1580-1645	1645-1805	1805	
Turkish	1250-1400	1400-1422	1422-1572	1572-1839	589
Austrian	1437-1700	1700-1813	1813-1866	1866-1918	481
Spanish	1479-1643	1643-1706	1706-1759	1759	
French	1594-1697	1697-1793	1793-1939	1939	
English	1607-1783	1783-1800	1800-1950	1950	
German	1800-1918	1918-1935	1935		

Another forecast made by Deulofeu, which is on the way to its fulfilment concerns Germany. A little time after the Second World War, Deulofeu affirmed that Germany would become again a great power because it was at the beginning of its second aggressive process, and that the French empire had started its decadence, the same as the British empire.

It is not the time to go through all the predictions which can be made in depth following Deulofeu's theory. This is a task which would demand a space and time which now we have not. Our purpose at present is only to attract attention on the man Deulofeu and his theory, so as to grant him the recognition which we feel he deserves.

Table 2: The Three Cycles Of Civilizations (Deulofeu, 1970)

First Cycle							
	Great Demographic Division		Imperialistic Period				
	Priest Aristocracy	Aristocracy of Wealth	Federal Phase	Unitary Phase	Decline, Disintegration	Servitude, Slavery	
Sumer	5250	4850	4600	4400	4200	3975	
Iran	5000	4600	4350	4150	3950	3725	
Egypt	4550	4150	3900	3700	3500	3275	
Baluchistan	3500	3100	2850	2650	2450	2255	
China	2850	2450	2200	2000	1800	1600	
India	2700	2300	2050	1850	1650	1400	
Greece	2700	2300	2050	1850	1650	1400	
Second Cycle							
	Great Demographic Division		Imperialistic Period				
	Priest Aristocracy	Aristocracy of Wealth	Federal Phase	Unitary Phase	Decline, Disintegration	Servitude, Slavery	
Sumer	3550	3150	2900	2700	2500	2275	
Iran	3300	2900	2650	2450	2250	2025	
Egypt	2850	2450	2200	2000	1800	1575	
Baluchistan	1800	1400	1150	950	750	525	
China	1200	800	550	350	150 BC	50	
India	1000	600	350	150 BC	50	250	
Greece	1000	600	350	150 BC	50	250	
Third Cycle							
	Great Demographic Division		Imperialistic Period				
	Priest Aristocracy	Aristocracy of Wealth	Federal Phase	Unitary Phase	Decline, Disintegration	Servitude, Slavery	
Sumer	1850	1450	1200	1000	800	575	100
Iran	1600	1200	950	750	550	325	100 AC
Egypt	1150	750	500	300	100	125 AC	550
Baluchistan	100 AC	300	550	750	950	1175	1520
China	450	950	1200	1400	1600	1800	2450
India	60	1050	1300	1500	1800	2025	2450
Greece	60	1050	1300	1500	1800	2025	2450

Part II

1. Subject layout.

During a long time human beings lived in relatively small communities which have spread more or less almost all over the surface of the earth. Little by little we have been able to gather knowledge concerning our surroundings and the necessary techniques to improve the efficiency in the extraction of the energy we need for living and increasing our population. When a species depends only on its innate abilities to survive (to obtain food), its population varies depending on the availability of provisions. Mankind has been able to escape, at least temporarily, from this dynamics, through the accumulation of knowledge and the development of technology, which allows us to attain new possibilities (adjacent possible) to carry on our growth.

In this case, nothing has been done in a planned way. At every time we have faced the challenges we had in front and have given them the solutions which were available. Some times it has been a brilliant idea, but most of them it has just been by accident.

Our ability to establish a relationship of cause and effect has allowed us to move forward by the method of trial and error. In this way, human groups have built up a collective knowledge which has gained ground in time, but whose main feature has been a shared knowledge. Even if it has never been shared in an equalitarian way (asymmetrical distribution), the way in which it has been shared out has had and still has important consequences for the way in which societies have organized themselves. Societies have become a network of dependence relations which have given each social group some given advantages, depending on the knowledge and techniques the group already had. Each one of these groups can play its cards in such a way as to obtain advantages in its own benefit. At the same time societies have become complex structures which need an always greater energy flow in order to keep growing. Now and again this flow diminishes, either because it has run out or because the access to the available energy sources has been interrupted, or because the greed of some groups in the societies, trying to hoard the resources, deprives the others from the sources necessary to their keeping, and as a consequence for that of society as a whole according to its structure at that time. Often, after the breakdown, new actors appear and the relationship among those existing is renewed, and so a new way is found to start growing again.

In spite of the efforts of the economic science to explain the origin of wealth and what should the governments do to get it, it is very difficult to think that this task may some day succeed, since it is facing a parameter which it cannot control, such as the population increase.

In the periods in which the different social groups have been able to be replaced from one generation to the other, without great changes, society has remained also stable. When the balance is broken, either because there are individuals who remain outside the system and do not find a way to keep in touch, or, on the contrary, because some roles cannot be maintained, society cannot reproduce itself under the same conditions. In both cases tensions appear which may cause a loss of complexity of society.

At present, a distinction is made between extensive growth and intensive growth. The old empires, based on agrarian economies, carried out basically extensive growth, while modern industrial economies are based more on intensive growth, in spite of the fact that they also need to open up to new markets to sell their production. The only important implication to be kept in mind is that the intensive growth demands the increase of the technological capacity of society.

We should keep in mind that also agricultural economies have produced intensive growth, and still do so, even if on a lesser degree as compared with other economic areas.

It is a serious mistake to believe that present day industrial societies are different from those of thousands of years past because they have a more advanced technology. The dynamics of societies is more related with the relationships which take place among their elements (individuals, cities, classes) than with the sort of technologies which are used to obtain the necessary energy.

It is true that, while it is easier to get the necessary energy through territorial expansion, probably it will not happen that the stimulants arise to find new technologies allowing to profit from other energy sources. When the industrial revolution takes place, even with ups and downs there is an important improvement of the living conditions in one part of our planet. This apparently produces a trend to reduce the desire for waging war in some countries, even if not as a general tendency. But here we must be very careful as we are moving on dangerous ground. The examples of violence which broke up in the nineties of the last century in the very heart of Europe must make us very cautious, and make us see that in any place, when there are changes in conditions which allow an apparent balance, armed conflicts may break out.

The decisive fact is that, when the growth possibilities, whether intensive or extensive, become exhausted, societies start facing problems.

2. Finding common concepts.

In order to compare societies in the course of time we need categories to be used in every time period. Most of the indicators which are used to analyze modern economies cannot be applied because there are no data available. But beyond this practical problem, categories must also be re-considered from a conceptual point of view. *Which theories should be ap-*

plied? In my opinion it would be proper to use ideas which may be applied to any time period, therefore they must be general ideas. One of the difficulties which appear when we approach these topics is that many of the theories applied in the beginning were related to very definite historical periods, such as feudalism or capitalism. This may cause confusion, because it becomes difficult to separate peculiar features of a given historical period from those which may be related to a concept which we want to apply to other historical periods. This will imply a greater abstraction task than what has been done up to now. At the same time, using an idea such as feudalism for different historical periods, may cause us to think always of European feudalism, which is the one which was originally defined as such.

In this paper there is no room to approach in a totally satisfactory and thorough manner this topic, but we would suggest some possible candidates to be used as common concepts. It is not a full list of concepts, only a first attempt to introduce some of the likely candidates.

The energy consumption.

Even if it is not possible to determine the exact consumption, some approximate estimates can be made for each time period to start a discussion on the relative consumption flows.

Civilizations and the so-called historical societies are human societies which have been able to obtain an amount of energy higher than the one needed just for their reproduction. This fact puts them in a situation of a growth dynamics. This growth often produces an increase in population, but not always. Some individuals in the society will be able to get hold of more surplus than others. When this becomes a hierarchical organization of the flows, usually it goes together with a political hierarchical organization firmly structured.

The technology.

In order to obtain the necessary energy for manufacturing products we need technology. This includes the accumulation of data and know-how which will allow the production of the goods. We say technology in a very broad sense, since we consider *the military* also a technology which allows obtaining a production. In this respect, then, armies are a sort of technology where investment is made in manpower (the soldiers) plus machinery (the guns) to obtain a product (the booty) with a given output. Military technology, then, is used to add to the social network new territories from which a surplus is obtained.

Wars are a way of seizing energy, but from an economic point of view, in order to be profitable the value of the product obtained must be higher than its cost.

Soldiers + Guns -> Booty (treasures, men, revenues)

If this is not so, armies become a burden for the states. After the military conquests, the booty obtained appears under one or more of the following patterns:

1. Treasures, in the aspect of material riches which are directly seized;
2. Men (slaves), that means manpower which is captured to be later used as a workforce, and
3. The commitment of rulers, cities and subjects to regularly pay tributes to the new rulers.

Often, before the war starts, an emissary is sent to the city to be submitted to demand from it the payment of some sort of tribute if it does not want to be assailed. On other occasions the cities themselves, upon their own initiative, ask for protection or help from a third party in exchange for some sort of tribute. In this way the military business becomes a service: protection in exchange for income.

The degree of violence used is very variable and depends on circumstances we cannot analyze in this paper. What really matters in our discussion is that, thanks to the war business the social network expands and with it the complexity of society itself. *How far can a society grow?* It depends on each case. Certainly, geography is one of the limitations, but the sort of technology used by society will also determine its possible growth.

In time, then, when the war industry no longer offers a sufficient return, armies become parasitical structures which feed on the surpluses produced within the territory of the empire. While the social structure keeps growing, feeding on the energy flows which it gets outside its borders, the social body may keep growing without many problems. When the outer sources stop flowing, the inner consumption habits do not change and then society consumes itself. The following expression shows what we have just said.

$$\text{Inner Consumption} \leq \text{Inner Surplus} + \text{Outer Surplus}$$

On the one hand we have the inner consumption which includes consumption made by all the society members. This consumption will certainly be very uneven, but it will reach most of the people, so the degree of unrest will be relatively small. On the other hand we have on one side the interior surplus which will be made up of the products obtained through the farming and industry of the territory itself, and on the other the surplus seized beyond the frontier. When the flow of outer surplus starts to diminish, the burden of the inner consumption is more and more borne by the inner surplus. In this way the classes which are responsible for it see that their benefits diminish more and more. If this situation becomes extreme, it is very probable that they will decide to abandon the activity

and to find a different sustenance means. At the same time, when the military force diminishes – the sale of centralized protection – it will become easier for some territories to free themselves from the centralized power. Each population will have to adapt themselves and learn to live with lower flows of energy.

In this way the social body splits up in smaller units relatively more autonomous. The volume of exchanges diminishes, mainly the one which has its origin in the long distances. This fact may cause that, if there is a loss of supply of any goods necessary as input for a given technology, this will have to be substituted by another one.

Economic surplus.

The concept of economic surplus can be defined as the amount of production which remains after having taken all that is necessary in order to leave the economic system in the same conditions as it was at the beginning of the period. This includes both the food to sustain population and investments to replace the tools and machinery which might have broken down. When we use the surplus concept we are not considering the possibility that this might have been seized by any social group. While salaries and profits are already linked to a given social class, the concept of social surplus precedes the sharing out which will be done. The way in which this surplus is shared out will be a feature for each period. It is not an amount easy to be measured, since its volume will depend on that which at every time will be considered as the necessary amount to sustain population. But it is very useful as an applicable indicator. For a society to grow, it is necessary that its surplus be positive. When its volume diminishes relations in societies start to be strained. It may also be useful to establish which is the proportion of that produced in the land with respect to that coming from outside.

The energy consumption and the economic surplus are very much related the one to the other, and the way in which the energy consumption is calculated may modify the results of the economic surplus. On this matter it is very interesting to read the book by Georgescu-Roegen, *The Entropy Law and the Economic Process*.

The economic science came into being with the object of studying the exchanges among people which carry out exchange actions freely and rationally. But this is a clearly limiting process which excludes most of human societies, besides including an evaluation such as who is a *free person*. Therefore, in order to be able to embrace all the periods, it is better to be able to study all the sorts of *exchanges* which take place in a given society.

The exchanges.

Under which conditions may exchanges be made among individuals? Conditions may vary greatly and they involve the use of force, menaces and trickery or a full agreement among them. Every time period will im-

ply a different framework within which exchanges will take place. The word *exchange* is used here to indicate any change of ownership of the peoples' goods, whether it is by force or by consent. Every exchange takes place within a different framework. According to each situation, in the end every change of ownership will receive a different name: sale, seizing, theft, plunder, and so on.

When we give priority to a vision of society as a network where individuals are nodes which relate to other nodes by means of exchanges, the idea is to show this network's structure and how it evolves in time. Energy circulates through it and as this goes on the network grows and integrates new nodes, thereby modifying the relationship among them. In this way the social body takes shape, and little by little becomes more complex.

How citizens participate.

Another way in which the evolution of societies can be measured, is the degree of participation of individuals in making decisions concerning the public area. All through time this participation changes. In some periods there is a higher participation and the power is shared out, while in others the concentration of power is very high and the participation is much reduced. Between the two extremes, societies find themselves immersed in processes aiming at the concentration of power, or, in the opposite direction, aiming at a breaking up of political power.

Ideology.

In this matter anthropologists use a much more explicit language when they say that societies, in order to maintain the levels of inequality among individuals, need an ideology to justify such inequality (Yoffee, 2005; Claessen, 2002). It is odd to observe that this language, which appears normal when used by anthropologists, it is not used equally truthfully in the analysis of modern societies. It may be because, when societies are analysed from the point of view of social sciences, in some way their inequalities are being justified.

Social reproduction.

In the same way as cells renew themselves in living beings, in societies individuals are replaced generation after generation. But this process does not happen in a planned way. Each family decides the number of children they want to have, and this fact together with the possibility that children do not take up the same trade as their fathers, causes the substitution process not to take place always automatically. Often the children's surplus will have to make a living in another place and possibly in a different way. When societies are immersed in a growth trend it will be easier for new individuals to find a position within the social network which will allow them to obtain a part of the surplus. But as soon as this stops being so, tensions will break out. It is true that there are longer or shorter time periods when societies appear to be stable, but sooner or later imbalances will appear. All this causes societies not to be motionless. They are never in a perfect balance.

Social structure.

It shows two levels: the first one is the social division of work, in the second one flows are established among the social layers for the distribution of surpluses. In order for a society to stay in balance it would be necessary for individuals which disappear in a time period in each social layer to be substituted by the same number in the following. When there are changes, even if they are small, their build-up in the course of time will finally produce tensions which will cause changes in the social structure or in the redistribution of surpluses.

3. The dynamics of the Mathematics of History.

We shall try now to describe the same process which Deulofeu explains, adding the concepts which we have just submitted. As in Quentin Tarantino's films, which are narrated from the point of view of different characters, we shall try to explain the same story from the point of view of complexity, of the flows of energy and of the emergent systems. We shall not try to exactly state the length of the processes from a theoretical point of view, because we have not got the elements to do so. Unless otherwise demonstrated, we shall accept those proposed by Deulofeu.

Deulofeu's arguments were based on the constant imbalance of each time period. Every time we find the seed which will take change towards a new social organization. Neither shall we give a detailed description of all the social process, on the contrary we shall centre on the more general aspects related with the concepts we have submitted in the previous paragraph, and which in my opinion may help to demonstrate that Deulofeu's description fits very well the approach of complexity.

At the time when societies start their social process, their social structure scatters geographically. Their interconnections are feeble on an extensive level. Even if there is a given exchange, the population nuclei are basically self-sufficient. At a given moment there happens what physicists call a phase transition and suddenly the economic activity increases. The possible causes of this leap may be mainly technological and demographic, but we cannot tackle its analysis here. Population and surplus start to increase and this implies an increase of exchanges. Surplus increases not only in quantity but also in its diversity. So new trades will appear which will increase the complexity of the social network. The dependence among individuals increases, and as a result the facts concerning a sector may have consequences in many others. Saying it with other words, the energy flows among individuals and social groups are interconnecting among more and more nodes.

The increase of wealth and its distribution will alter the power relations among those who had the control and power of the social group up to now, and the new *rich* who have sprung up through the accumulation of wealth. As a result of the development of the social reproduction a new social hierarchy is born which will end up acquiring also the political power.

During the whole process, cities will have kept growing and agglutinating most of the population increase. At a given time inside the cities tensions start to appear, either because the generated surplus can no longer cover the unceasing increase of population, or because the distribution of the surplus has been channelled mainly towards the ruling social groups, leaving most of the population in an impoverished situation.

Inside the cities the situation becomes more and more complicated to such an extent that the ruling classes ask for the help of a neighbouring city as a last resort to stop the social unrest. In this way the city bringing help gives vent to its own inner tensions, using a part of its population surplus as an army to help the ruling class of the other city to control the situation. The city giving help finds a way to obtain an energy flow from the tributes that from now on it will obtain from the city it is protecting. At the beginning it is not a will of political control which moves the original expansion of the city, but an exchange between armed force and money. In so doing the protecting city discovers a new technology (the military one) which supplies a new source of income. Little by little the army will become more professional and one of the more important industries in the city.

In this way empires start their expansion. It is not an activity planned for the long term, but the result of decisions taken in the daily strategy to solve the problems the rulers have to face. Without any forethought, cities find themselves immersed in a process in which they are competing with each other, and in the end one of them becomes the imperial nucleus. In so doing it manages to channel towards itself most of the energy flows which are generated in the territory it controls.

The complexity of the empire will now have increased considerably as compared to that of the human groups we found at the beginning of the process. At this moment there are many trade areas which are linked among themselves, a great variety of social institutions, which have been created in the course of time, and a large territorial extension with many towns and cities also linked among them by all sorts of trade relations. All this causes the social body to be able to absorb the small disorders caused by outer factors, but it makes it also extremely dependent on the energy sources from where it gets its surplus. Seeing the usual way in which social evolution takes place in the prosperity periods, we can affirm that this has always taken place up to now through economic growth. This fact causes that every time larger energy flows are needed to generate more surplus, but at the same time there is a limit. Either because the territories liable to be conquered are finished, or because technology has reached its end, there is a time when the surplus comes to a standstill or starts to decline.

At this time the decrease of the energy flow causes a competition to develop among individuals, social groups and cities for the obtainment of the resources which are still available. The old imperial ideology which had

been useful to justify the aggressive processes stops being useful. Everybody will try to find a way not to pay taxes and to hold all the surplus they can. The result of all this will be that little by little the social body will start to fall to pieces. The imperial nucleus will see how the incomes coming from all the territories diminish and as a consequence its intimidating power.

This process will go on, we might say in a replicating way, in all the social units which break their links with the imperial nucleus until a state of demographic fragmentation is reached, more or less similar to the one we found at the beginning of the process. When this point is reached, the important thing is not the state the technology may be in, but the amount of relations among individuals, social groups and cities which have been strongly reduced. The social network is again weak and small.

4. On the onset of History.

In the previous section we mentioned the leap which takes place when the social process starts, as compared with the phase transitions mentioned by physicists. We cannot go into this subject in depth, but it is worth while to make some considerations which we submit herewith.

The human species appeared on earth millions of years ago, and during a long time it occupied almost the whole planet. Little by little the density of human settlements increased until a time came when in different places on the planet there started to appear what we later called cultures and civilizations. On the other hand, in other places which were also inhabited, civilizations did not appear until later and in other places they never appeared. We are not going to discuss this matter here, on which the best known contribution is that by Jared Diamond – *Guns, Germs, and Steel* – (Diamond, 1971). In the field of anthropology there has been a strong discussion about which were the necessary conditions for the formation of the first states.

At this point it may be very useful to remember the conditions submitted by Claessen for the appearance of the states (Claessen, 2002). In his opinion, for a state to appear the following conditions are necessary:

- * There must be a sufficient number of people to make up a complex, stratified society.
- * This society must control a specified territory.
- * There must be a productive system yielding a surplus to maintain the specialists and the privileged categories.
- * There must exist an ideology to explain and justify a hierarchical administrative organization and the socio-political inequalities.

It appear clear then that there is a crucial moment when what physicists call a phase transition takes place, and human settlements stop being simple tribes or gangs and start their journey towards more complex societies, which will finally run into what we call civilizations. At this point a

different trend appears which leads them towards a more defined division of work and which translates into an increase of the exchanges and of the dependence relations among them. History begins...

It would be at this point that the law of the Mathematics of History would start to work as an emergent property, being the result of the increase of complexity. Certainly, this increase has its origin in the birth of farming, which caused the control of the necessary energy flows to insure a more regular sustenance, instead of depending only on harvests and hunting. Notwithstanding the irregularities caused by climate on the farming results, farming technology fostered the first step towards the obtainment of a more or less regular energy flow.

This is a vital factor which, together with the fact that most of the times these flows are higher than what is needed to maintain the same number of people, caused societies to become larger and larger. In this way there appeared the challenge of how to integrate the new individuals to society. *Which jobs could they do? If the basic production for sustenance was already granted by the other people's work, what could the newcomers do?*

If we accept that the Mathematics of History appears as an emergent law, which starts to operate at the moment when some given initial conditions are present, or as Spier calls them, some given Godilok conditions, then the following question also appears to be relevant: is there a limit in the upper part of the social aggregation which determines at which point the law would stop operating? In the theory of chaos it is accepted that some given behaviours can be foreseen in accordance with some laws which operate within some limits, but outside them they stop doing so. Saying it another way, if the world integration process goes on, would it be possible for these law to stop operating? This is a purely speculative field on which we shall return in the conclusions.

5. Criticism on cyclic theories

In his study on the break down of complex societies, J.A. Tainter makes a review of the several cyclic theories (Tainter, 1988). With good reason he says that the reasons brought forward by most of the cyclic theories are based on mystical factors. These *mystical factors* are not supported by empirical data and use terms such as decline, vigour or senility.

Cyclic theories have always had defenders which have seen in societies a development similar to that of animals. But to explain the evolution of empires only with mystical metaphors (youth, fullness, decline) is not at all convincing, as indicated by Tainter (1988). To explain the fall of an empire by the fact that it is declining, or to justify its expansion by the fact that it is young, are not convincing enough claims to make these theories believable.

But even if up to now the justifications given to defend cyclic theories are not convincing, there is no doubt that in the course of time they have had

an influence on many masterminds. This must make us think if there is not some sort of evidence to justify this periodic revival of these theories. There is one indisputable fact: cultures emerge and in due time disappear. *How is this to be explained?* Certainly, it is not an easy matter, and with the theoretical tools available to science until a short time ago, it was almost impossible. Masterminds have worked more in the field of intuition than with a discourse based on believable scientific debates.

Besides, as Tainter himself points out, these theories do not make any reference to empirically knowable processes (Tainter, 1988, p. 74). We may then reduce criticism to cyclic theories to two points: in the first place discussions which are not based on any scientific discourse, and in the second place a lack of empirical data to sustain the discourse.

In my opinion, none of these two analyses can be applied to the Mathematics of History. It is true that Deulofeu uses the terms decline, fullness, youth, which are typical of cyclic theories, but it is also true that he always explains the inner tendency whereby these societies evolve the way they do. There is no doubt either that his arguments may today be improved by using the most modern concepts developed around the theory of complexity. This fact should not catch us unawares either, since the theory of complexity has appeared as an explanation of the birth of life. Therefore, those who see a likeness between the social body and the animal one, should not be surprised that the theory of complexity had something to say with respect to the evolution of societies.

As far as the second point is concerned, Deulofeu establishes in a precise way the dates which mark the different time periods within the evolution of civilizations. Something different is to check if he was right in all his work. but to find out it would be necessary to make a strict revision of his work to be analysed, in the light of the present day situation of historical knowledge, and the total or partial validity of the same. This work has not yet been carried out and it would imply at least to grant some sort of credibility to his propositions.

The news submitted by Deulofeu are not cyclic evolution in itself, but to provide a believable inner tendency and to pinpoint exactly the time periods of each civilization.

Besides Toynbee and Spengler, Tainter also points out Alfred Kroeber's work as one of the authors who, in the first half of the twentieth century developed cyclic theories concerning the evolution of civilizations. This author, who was focused more on cultural evolution, established cycles of creativity in arts, philosophy and science, and pointed out that the Egyptian civilization rose and fell four times before it disappeared. According to Kroeber, cultural processes are characterized by the development of a pattern which is created and searched until it runs out (Tainter 1988, p. 81). This idea is also to be found in Deulofeu. Creativity is just the exploration of a number of possibilities. The essential step is to find the starting point which will open the way to the other branches. Even if the summary

we have made of Deulofeu's theory has not been fully developed, his theory embraces all the fields of human culture, not only the political and social processes.

In my opinion, there are several aspects which muddle up the possibility to compare present-day societies with those of thousands of years ago. Perhaps the most outstanding of all is that of material progress. In the following section we shall tackle this matter. Another point is the role of violence and wars in antiquity as compared with today. Notwithstanding the fact that we are all aware that wars have not disappeared and that violence is still very present all over the world, it is true that often in learned environments there is the notion that in our present day *civilized* world violence is an attitude which little by little is being confined to the most *backward* countries and to very specific areas of society. This notion conceals an evaluation which luckily is becoming less and less common.

Finally, there are two more aspects which, even if they are more subtle, they still have an important role. The first one is that of human free will which would make it impossible to be submitted to external laws which would condition our behaviour which is determined by our freedom. The second aspect is the opinion that past errors will not be repeated. We shall also tackle these matters later.

6. *Cyclic evolution and material progress.*

One of the elements which make it difficult to consider trustworthy Deulofeu's theory is the role played by the material progress of mankind within his theory. It is difficult to accept the idea that material progress has been fluctuating all along history. This however does not mean that there are not time periods in which some knowledge is lost. The technology used at any time depends both on the acquired knowledge and on the available resources. Therefore, if a resource is no longer available, the technology which used it will be abandoned. The technologies used at any time are changeable, but these changes are not always the result of progress in learning, they are above all an adjustment to the resources available for society.

Technology must then be seen as one of the pieces on which the social building is being constructed. In the course of time the pieces used (the building materials) change, but *buildings* are still being constructed. All this is very similar to what Spier says when he affirms that the "cultural change will overcome genetic transformation as a prevailing adaptation mechanism" (Spier, 2010).

As we said previously, mankind could *escape* from the law which regulated our population as one more species, when they started using *exosomatic* instruments. But apparently, after that we fell under another law which is ruling us, and at the present moment we do not want to acknowledge its influence on us.

The first civilisations depended more on geography to weave their communication systems. Nowadays we are used to see cities springing up in the desert, artificial islands, motorways through the jungle, and water being transported for hundreds of kilometres, but the old civilizations had to take advantage of the natural conditions of geography in substitution for what today we call infrastructures. So they took advantage of the natural conditions to weave the communications network necessary to their economic exchanges. In time, rivers have stopped being the main thoroughfares used by societies, and this has allowed to extend the extension range covered by the *civilized* territories.

The thesis I am suggesting is that cyclic history of civilizations is based on the evolution of the degree of complexity that societies can reach in the course of time. It is a history of their complexity. Technique and economy are the dress they wear. The role of demography is surely more connected to social evolution, because if we associate history to the complexity of societies, it appears that demography must have an important role. The increase of social complexity must be related to demography.

We go back to the discussion concerning material progress and the objection to cyclic theories, which cannot explain it. My opinion is that cyclic models must not try to explain material progress. This is something else. It is clear that progress and human knowledge, even if they face ups and downs, have been on the increase since the beginning of historical times. This progress has gone beyond civilizations. The network of knowledge is a global network, which has been spun since the beginning of history. It has grown in intensity and extension, and in the latest periods it has accelerated itself in a noteworthy way, but it exists since a very long time with different rhythms. Which should then be the aims of a cyclic theory of history? On the one hand, to study the evolution of the power networks, to see how the different social agents evolve with respect to the power they have attained. This includes basically social classes and cities. On the other hand, they should study the cultural evolution of the peoples and see which is the relationship to the political evolution.

According to Stuart A. Kauffman, there is a cellular watch which shows the change in the composition of the cells amino acids. In this respect the position of species within the evolution tree can be determined. In the course of time complexity has increased, every time there are new amino acids which were not to be found in the extinguished species or in those which have a previous formation. But all the individuals of any species have a given life span, some are shorter or longer than others, but for all of them the time arrives when they cannot keep their organization working and die. The cell type and composition do not matter.

Something similar happens with human societies. In the course of time we have created a greater diversity of products. At present, some societies enjoy a degree of material wealth much higher than that of the preceding societies. But this fact has little to do with their survival ability and their

vitality. It is wrong to mistake material progress and its distribution with the way societies are organized and which are the economic circulation networks which are under them, and this stops us from *marking out the social process from the material process*.

Material process has to do with the amount of different products we are able to make and how we can distribute them. Social process is more related to how the power network is organized among the different actors which make up societies and which are the dependence relations which are established among them. All the organizations need an energy flow to keep going. When societies have difficulty in maintaining the necessary flow, very probably their structure will be finally modified.

While a society maintains its expansion ability, either increasing the territories it controls, from which it can obtain more resources and energy sources, or by increasing the productivity of the technologies it is using, the wealth flow absorbed by such society will be used to create a more and more complex and sizeable society. Social tensions within this society will be few, because even if riches are not distributed in an equalitarian way, nonetheless it will reach all the social sectors.

When society becomes unable to continue its expansion, the classes which were used to receive a continuous wealth flow cannot renounce, and being unable to obtain it outside the nucleus they try to get it from society itself. This will be the beginning of the decline of society, the social structures which had been built up to then will start to break down and slowly society will lose weight.

Biology has taught us that living beings have in their genes the instructions which lead them one way or the other in their growth and in how to build their bodies. But apparently there are no instructions on how the upkeep should be made in order to avoid the aging process. As far as societies are concerned there are no instructions on how societies should build up, but in any case it appears that while there is a growth tendency (obtainment of more resources with population increase) this is not very important, because societies themselves find the way to increase their complexity. The problem arises when they become exhausted, or the energy sources are cut down. The competition to obtain the remaining resources quickens the disintegration process.

7. Breakdown of complex societies and the Mathematics of History.

One of the central points of my reasoning consists of emphasizing that Deulofeu's argumentation is not very different from that of other authors, even if his final results are more astonishing. His explanation is different, but it is essential to point out that they are not contradictory explanations, but they are complementary with each other. In order to explain this we shall briefly go over Joseph Tainter's work, *The Collapse of Complex Societies* (1988), and Cipolla's article, *The economic Decline of Empires*

(1973). These two authors reach very similar conclusions within the framework of Deulofeu's theory.

According to Tainter to understand the decline of societies four concepts must be kept in mind:

1. Human societies are problem-solving organizations.
2. Sociopolitical systems require energy for their maintenance.
3. Increased complexity carries with it increased cost per capita.
4. Investment in sociopolitical complexity as a problem-solving response often reaches a point of declining marginal returns.

In this respect it is considered that there are two factors which combine to make societies with declining marginal returns to become vulnerable. In the first place, the tensions and disturbances which are a feature in complex societies. All societies have suffered bad harvests, border problems and internal uprisings, but most of the times they can stand up to them if they have the necessary stocks. In the second place, when the societies have declining marginal returns or productivity, the increase of complexity is no longer a good strategy to solve the problems being raised. This will make the reduction of social complexity a more efficient answer to deal with the tensions society has to face.

When empires are in a *declining* phase they lose the aggressivity they had before and have difficulties to tally their budgets. They have reached the bend segment which starts the declining marginal returns or productivity. The central government loses strength because it sees how its incomes diminish, and the cities and peoples start to consider a solution to get free from the central government which is strangling them economically. If the political power network gets lighter the amount of energy necessary to run the system decreases. Under these conditions, a declining empire has higher costs to maintain sociopolitical structures than the incomes it receives from the available energy sources (Tainter, 1988).

We shall summarize now Cipolla's viewpoint. In order to decline, an empire must first grow. Growth implies an increase of incomes, and also an increase of consumption both private and public. The standard of living improvement at the beginning only takes place in a reduced circle of privileged persons, but in time the process reaches out to larger and larger sectors of population. One way or the other, the common people will succeed in taking part of the well-being enjoyed by the higher classes. At the same time as society develops, it becomes more conscious of social and collective needs, which may take different aspects. In mature empires public consumption shows a clear tendency to grow. Population quickly becomes used to improved life conditions, and the central powers accept the increase of public expenditure in exchange for the population's support. This support, which in the past was obtained through ideology,

now it is obtained through the improved living conditions. In this way, more and more individuals think of rights and not of duties, of enjoying and not of working (Cipolla, 1970).

At this time, the flow of energy obtained by the empires falls, but needs are now much higher than before and social tensions start to appear. The public sector bears strong pressure on the private sector in order to ravage as much as possible the possible resources. Consumption vies with investment and vice versa. Within the private sector the conflict among social groups increases because every group tries to avoid as much as possible the necessary economic sacrifices. As the struggle increases the cooperation between the people and the social groups diminishes, a feeling of estrangement appears with respect to the community and with its group and class selfishness (Cipolla, 1970).

During this phase, within the empire itself intellectuals appear which wonder what can be done to re-vitalize the country's economy and to increase its productivity. But even if there are individuals who see the need for change, it is typical of mature empires to give a negative answer to this challenge.

Cipolla points out that even if innovations are important, there are empires which were able to grow and develop without any need for modernization in the economic field. Perhaps the most remarkable case is that of the Spanish empire. It is clear that innovations take place when an alternative is needed to a course which is becoming exhausted. It is therefore understandable that, when there is an easy energy source, there is no need to look for alternative ways.

With respect to the role played by innovations in the evolutionary process of societies, it is interesting to point out Cipolla's viewpoint when he says that "innovation is for society what mutation is in biology".

"Innovations are important not for their immediate, actual result but for their potential for future development, and potential is very difficult to assess. Innovation is to society what mutation in biology. Not all mutations are good. Some are just poor and unfortunate experiments. Only natural selection will tell over time which are good and which are bad mutations"(Cipolla, 1970, p. 9).

8. Could historical simulations be made?

The claim that history may be a science going beyond the recital of facts and suggestions concerning the causes which may have had an influence on their outcome, opens the door to some important questions. *If there are laws for social evolution, is there a way to prove it? May experiments be made? Can historical simulations be finally made?* Until not long ago, the answer to the last two questions was clearly no, but today, with the introduction of computers the answer cannot be so forceful. The discussion is open and there is already a significant number of researchers who say that this is possible.

Also in this case anthropologists are among the pioneers to realize the possibilities offered by simulations with computers and have started to use them to compare actual settlements with simulated ones (Kohler, Gumerman, Reynolds, 2005). But one of the first remarkable works, which opened the doors to this field of study, was that of J.I Epstein and R. Axtell, *Growing Artificial Societies. Social Science from the Bottom up* (Epstein & Axtell, 1996). This work showed the actual possibility to make social simulations based on autonomous agents having individual behaviour features which, through interaction, in the course of time give rise to different general behaviour models.

It is to be pointed out that from the agents interaction may spring up not only competitiveness models but also collaboration ones without a previous programming to hold this conduct (R. Solé, 2012).

It will not be an easy task, but I believe this track is worth exploring. At the beginning simulations will have to be partial and centred in particular and actual aspects. But with the experience obtained the experiments will become more perfect, and at the same time it will be possible to check the possible effects of the different agents' behaviours.

Under some respects it concerns doing something similar to the attempts to obtain artificial life in the laboratories. Success is not granted, but it is a path that we cannot afford to waste. I imagine there will be criticism rejecting the validity of the assumptions, or that human behaviour cannot be simplified in some computer instructions. That human behaviour is much more *complex*! Here it will be good to remember that complexity rises out of simplicity.

Will it be possible to work out the agents' behaviour and the environmental norms in order to produce the growing complexity cycles alternating with cycles of loss of complexity? I think it is a challenge we should accept without being afraid of failure. Or perhaps are we afraid of just the opposite?

The *dangerous idea* that the laws governing nature spring up as emergent phenomena is often difficult to accept fully (Dennett, 1996). If we accept the history of mankind as a part of nature, why should we give up studying it as if it were something different?

9. Open topics.

Deulofeu's theory does not cover all the human groups which have filled the earth, but it does cover virtually all the cultures and civilizations. We shall now analyse some of the issues which appear after considering Deulofeu's theory. It is not a full account, just a rough estimate to start with.

In the first place we shall try *to fix the limits* within which his theory would be conclusive. We have tackled this matter when we talked about the beginning of history, but it would be interesting to be able to tackle it more in depth. *What happens when the three cycles have finished? Isn't it possible to start new cycles?*

Another interesting issue concerns *why is the cycles' length so exact? Couldn't they be variable?* After all, all living beings, even if they go through well defined phases, have a variable life span within some limits.

Another aspect which should make us think is that in the present world, the whole of earth has been parcelled out in countries. This causes that any aggressive process to get new territories from now on will have to be at the expense of some other country.

Finally, an issue which had already bothered Deulofeu, that is the possibility of avoiding wars as a consequence of knowing the law. *Would acknowledging his theory help to avoid the disastrous consequences of the social processes?*

We have no answer to these questions, but it is necessary to ask them in order to know which are the points which mark the boundaries of our present knowledge.

10. Conclusions

But even if this argument fails, I hope it may provoke comments or ideas that stimulate further progress towards the construction of unified paradigm for the study of the past on the very large scale. (Spier 1996, p.2)

In this paper I have tried to make known Deulofeu's work, a Catalan historian of the twentieth century which developed a theory called *Mathematics of History*. This, besides being another cyclic theory, is an attempt at a thorough renovation which explains the evolution of civilizations based on the inner dynamics of the agents which make up society: social groups, cities, peoples, ruling classes, etc. On the other hand, Deulofeu situates exactly the time periods which make up the different stages the peoples go through. There are not superior peoples. Depending on the moment they are in within their cyclic process, they will be more creative or they will be in a more aggressive or more conservative stage, but there is no intrinsic feature of the peoples.

As all scientific theories, his work surely is not perfect, but it deserves being taken into account, discussed, revised and updated, or refuted if necessary. Being ignorant of it, hiding under one's bed, is not a justifiable attitude. The progress of social sciences needs open discussions without prejudices.

Comparing societies with the vital cycle of animals, even if it has been used as a metaphor, conceals many more similarities than could be imagined by those who did so the first time, or those who later criticized them. The theory of complexity teaches that through the combination of basic pieces, new structures spring up. The struc-

tures use up energy and pieces must be replaced. As a matter of fact, this also happens to societies. Societies are living structures, because their elementary pieces, individuals, must be replaced. Other pieces, such as technology, are also involved and are very important for structuring societies. Social structures change in the course of time, and the study of this change is the central point in Deulofeu's theory.

Deulofeu compares the period of demographic fragmentation to the gestation phase of living beings. Spier also says that there are a number of analogies between the emerging of complex animals and the coming up of farming societies (Spier, 2011, p. 149). Both multicellular organisms and societies share a similar phenomenon: the increase of the complexity derived from the intercellular division of work and the emergence of the social division of work.

In my opinion, Deulofeu's theory and the complexity theory can complement each other very well. It would now be necessary to put it into practice. To make historical comparisons among different time periods and different territories is not an easy task. It is necessary to have standards which may be applicable everywhere, and unfortunately, data are not always available. Even so, it must be tried. For this reason in my paper I have suggested some candidates to help us in this job. Of course, it would also be interesting to be able to update and specify some of the terms used by Deulofeu in his discourse. In this connection, I have made an initial attempt to rewrite my account applying these concepts.

I think that Deulofeu's work deserves being recognized, discussed and analysed, and to do so the first thing to do was to let it be known. Even if at a later date it were found that it shows serious mistakes, it is sure that in so doing we would learn many things, because the study of complexity is an unquestionable research process as a way to understand reality.

In the field of social sciences, nobody has made so many predictions based on a theory with so many guesses. Isn't this a good enough reason to grant him a credibility margin?

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