

Artificial Intelligence and Economics

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Abstract

The relationship between Artificial Intelligence (AI) and economics has been explored by numerous scholars, most of whom view AI primarily as a form of intelligence comparable to human intelligence. The perspective developed in this article is fundamentally different. Rather than considering AI as a substitute for human cognition, we approach it as a machine language possessing the essential characteristics of any language system. From this standpoint, the parallel with economics, understood as a scientific language for describing, interpreting, and transforming economic reality, becomes readily apparent. From an epistemological perspective, it is therefore essential to examine the structure of these two languages and to trace their historical evolution through the successive metamorphoses of capital. The transition from machine capital to financial capital, and ultimately to AI-based capital, reveals the broader context within which these transformations have occurred and sheds light on their economic, social, and political consequences. Such an analysis makes it possible to understand artificial intelligence not merely as a technological innovation but as a new stage in the historical development of capitalism itself.

Keywords: Epistemology, Artificial Intelligency, Inquiring Systems, Digital Revolution

I. Introduction

Economics and philosophy have followed parallel and sometimes even convergent paths of development. These historical paths have always been imbued with an essential element: language.

Today, the exponential development of algorithms and software related to what we agree to call Generative Artificial Intelligence (Gen-AI) obliges the economist, on two counts, to ask questions about this new agent that is disrupting our science.

On the one hand, how does it understand (and interpret) economic phenomena and what is the scope of the conclusions to which it could lead us? On the other hand, do the languages used by AI correspond to what our theories and models seek to explain (not without difficulty)? Can we accept in the name of who knows what axioms and postulates the "meaning" that sophisticated syntaxes (and even their semantics) could induce us towards economic policies and choices likely to disrupt our lives and our well-being, the ultimate objective of this entropic process to which the Economy leads us according to this scholar who was Nicholas Georgescu-Roegen (G-R 1971)

Could the language of AI one day reach the level of understanding of the meaning of the human brain as Hinton, recently declared: "We are biological systems, and they are digital systems. For the moment, they are not more intelligent than us.... But I think they will be soon" (Macuda et Al 2023)

The Digital Revolution, with all that it carries from our old theories, forces economists and philosophers to dive back into epistemology to try to explain the meaning of new theories of knowledge of intelligent machines. Because the articulation of meaning in economics and philosophy (especially in its epistemological and logical aspect) are already found throughout their history in and through the languages used by economists.

If philosophy - far from metaphysical dualisms - has a chance of existing tomorrow, it will be as a meeting point for the innovative effort of science, that is to say, as a Philosophy of Science or Epistemology. Philosophy needs science to "exist », and Scientia needs philosophy to « be », today more than ever in the face of the challenges of humanity. Only philosophy, as a total space, is capable of sheltering the social trends of technology and the languages (natural or artificial) of science that we perceive today as a sign of our time.

II. Systems Theory And Systems Epistemology

2.1. The concept of system

Modern epistemology is linked to « Information Theory » and its method is Systems Analysis. Knowledge is defined as a set of information, researched and systematized according to an individual or collective project.

This project therefore determines not only the set of relevant information and its domain, but also its use, that is to say science.

Shannon 1949 establishes the analogy between the organization of the system of signs, that is the message and the organization of any system whatsoever. Finally, it was Bertalanffy 1973 develops a "General Systems Theory" (GST)

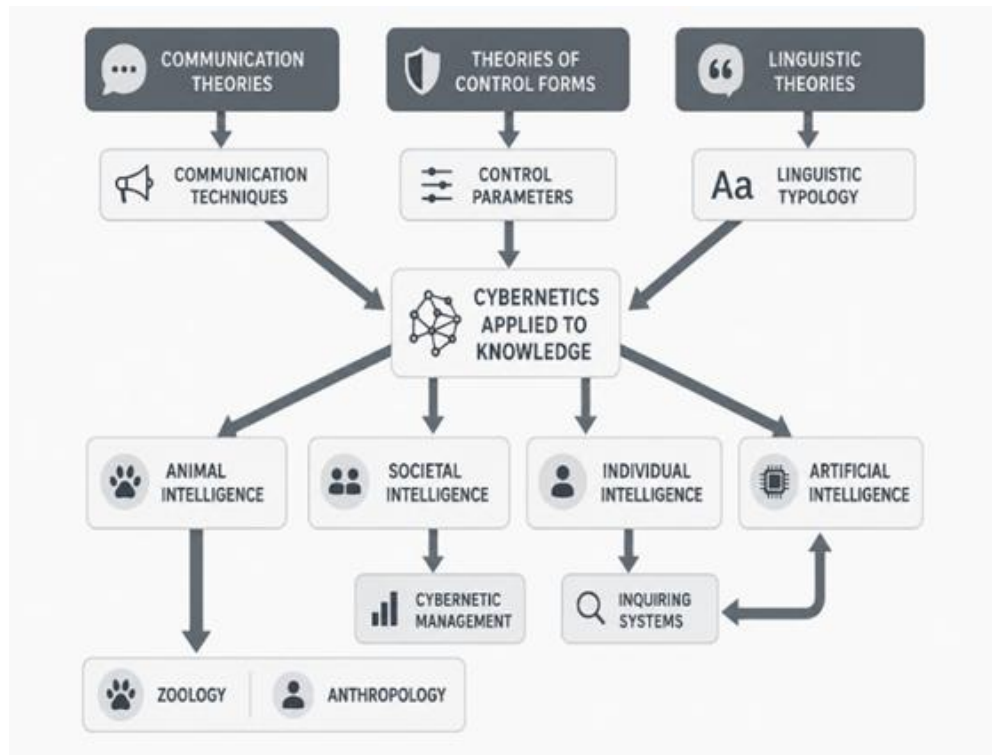
A system is therefore formally defined as a non-empty set of elements and linked by a non-empty set of relations defined between these elements. The elements can also be structures. Then, the system is defined as a set of structures put in relation, we cannot dissociate the elements of the structure nor the structures of the system since each element of a structure constitutes a Whole in relation to its parts but also a Part in relation to the system to which it belongs.

In reality a system is only a set of relations. We will limit ourselves here to analyzing a particular class of systems which concern, according to us, knowledge, their languages and the ways of knowing machines and artificial intelligence: cybernetic systems.

2.2. Cybernetic systems

Cybernetics is defined as the science of control: it is the study of the process that connects a system of inputs and outputs (inputs-outputs) with the internal structure of this system. It measures the system's ability to control the environment. (Wiener 1948 and 1961) define: "*Cybernetics studies the concepts of control and communication in living organisms, machines and organizations, including self-organization.*" *It is an interdisciplinary science born "from mathematics, logic, semiotics, physiology, biology and sociology"* Novikov 2016, p. 7)

The massive use of systems analysis in organizational sciences towards the end of the 20th century, was done through cybernetic systems, characterized by complexity and uncertainty. Two concepts are fundamental for this type of system: an objective and the control of the means to achieve it. We can situate our epistemological field of study, ("inquiring systems" or "research systems"), in the following Graph



Graph 1.1: Cybernetic applications (inspired by Novikov 2016, p. 10):

Among the applications of cybernetics to organizations, it was that of Beer 1959 and 1972, considered the founder of Cybernetic Management, which marked the future of the method. Beer gave control a very particular characteristic: "The first principle of control is that the controller is part of the system under control. [it] is not something that is stuck to a system by an authority [...] the control function is distributed throughout the architecture of the system." (Beer 1972, p. 26)

Cybernetics has also become a subject of study for philosophers, both in its ontological, ethical and epistemological aspects. According to Novikov 2016, p. 30, the philosophy of control has two different dimensions: one "cybernetic", the other "managerial", that is to say "theoretical" for the first, "applied" for the second, each with very different fields.

The cybernetic scientific dimension, control in the sciences, is done from the epistemological point of view on the research fields chosen by the sciences, their methods of investigation and the paradigmatic control of the "invisible college" (Kuhn 1970). The logical aspect is carried out by the control on the conceptual apparatus, the priority to a type of scientific approach (empirical, rationalist, etc.) and to "esoteric" languages with models all the more sophisticated as they are far from reality.

2.3. Invariance and teleonomy in cybernetic systems

In cybernetic systems, we also speak of variance and teleonomy. The first term defines the property that a structure has of being able to transmit "ne varietur" the information that is specific to it. Teleonomy is the capacity of living things "to be objects endowed with a project that they both represent in their structures and accomplish in their performances" (Ackoff 1973 p 661)

The GST (Pouvreau 2013) distinguishes two types of systems: the natural system made up of three subsystems: physical, biological and social and the cognitive system ("The Mind") and artificial intelligence. Each subsystem is made up of four axiomatic structures.

1. A structure that defines the properties of the system, state structure (structure α).
2. Two behavior structures that determine the relationships of the system with respect to the environment (inputs)
 - a) Cybernetics I: self-stabilization of the system by negative control (feedback) (structure β).
 - b) Cybernetics II self-organization of the system by positive control (feedback) (structure γ).
3. A structure that maintains the relationships between the parts and between these and the whole of the system, (hierarchical structure δ).

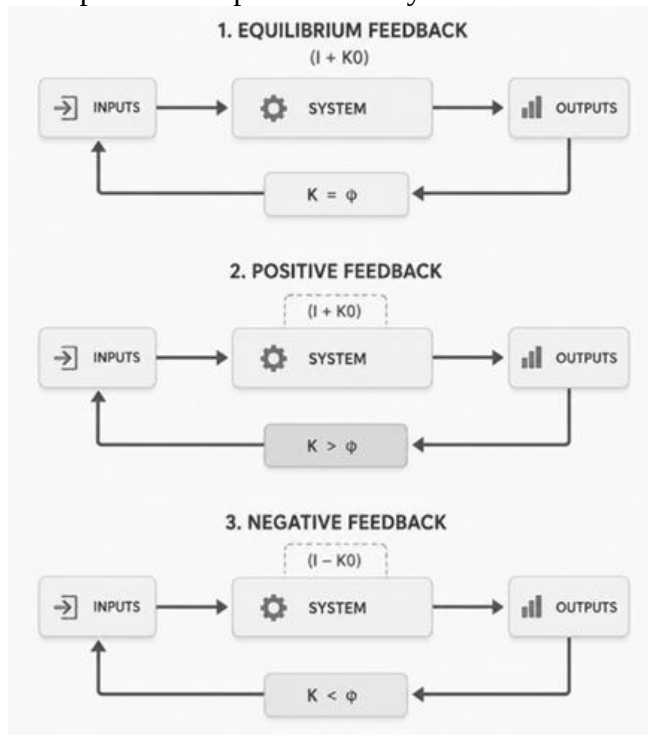
Although specific to any system, these four structures (α , β , γ , δ) present some specific differences, depending on the system of which they are part and in particular in the cognitive system, since any system produces entropy with respect to time so that the "disorder of a system increases at the rate dS/dt This entropic change is equal to the sum of the "natural" change and that which depends on the inputs, of the system (called "negentropic import of the system" opposed to the "second principle of thermodynamics" (2pt):

This thermodynamic conception means that a system can be in expansion, in contraction or be stable, depending on the control it exerts on the environment (its inputs). But any system (a cell, a corporation or a country) will not only have to respond to the stimuli of its environment but also to the inevitable degradation of its own structure. Stability only becomes possible through action

Consequently, the system will only be invariant to the extent that it exerts a control at least equal to its own entropic degradation or dissipation function of the system. In other words, the state of the system in at will only be the same in a $t+1$ if the cybernetic control exerted on the system is at least equal to its own dissipation. However, as in physics entropy is irreversible, this means that time (and history) is a unidirectional variable and the return in time also becomes irreversible.

Classical thermodynamics distinguishes two forms of energy: (a) free or available and (b) bound or latent. The 2pt explains the inevitable degradation of energy. Free energy (that which can be transformed into mechanical work) "dissipates" (transforms) into latent energy because the universe undergoes a constant qualitative degradation of energy, until "total death".

With ϕ the dissipation function and k the control variable ("cybernetic control"), Figure 1.2 shows the three cybernetic types where **I** is the input, **O** the output and **S** represent the "system"



Graph 1.2: Three cybernetic types

2.4. Systems and Thermodynamics: Information Theory

The Second Principle of the Thermodynamics (2PT) tells us that: *"Any transformation of a thermodynamic system is carried out with an increase in the overall disorder including the disorder of the system and the disorder of the external environment."* We also say that there is creation of entropy because the entropy state function: S , is a measure of disorder."

$$\Delta S_{\text{global}} = \Delta S_{\text{Creation}} = \Delta S_{\text{sys}} + \Delta S_{\text{ext}} \geq 0$$

In the case of a reversible transformation, the creation of entropy is zero, which is considered a textbook case since physical phenomena are irreversible: nature follows an arrow of time on a trajectory with no possible return.

This 2PT governs research in physics and will be considered an inviolable axiom of the laws of nature. It was not until 1867 that a purely theoretical experiment (the "Maxwell Demon" MD) would raise doubts about the inviolability of 2PT.

This experiment consisted of a watertight partition separating an isolated volume of gas in thermodynamic equilibrium, i.e. the hot and cold molecules were each on one side and the other of the container. But a "demon". acts on the door of the container and opens and closes it depending on whether the molecules hitting it are fast or slow. Gradually, one compartment heats up, the other cools down. The entropy of the whole, although isolated, decreases. (Knott 1911, p. 213-214)

However, for Prigogine and Stengers (P-S 1959), it soon appeared, during the 20th century, that many phenomena, notably chemical reactions and in particular biochemical processes, such as those which govern the metabolism of living beings, take place far from any thermodynamic equilibrium.

The founding idea of this "Third Stade » of Prigogine thermodynamics is as follows: when the external constraints applied to a material system are large enough (for example certain phenomena in nature) to keep it far from equilibrium, this system can prove to be unstable. Simple random internal molecular fluctuations – destined, in the case of stable systems, to attenuate spontaneously – can then amplify to the point of producing large-scale effects and driving this system towards singular operating regimes, which can only be studied on a case-by-case basis. In other words, contingent exceptions exist that contradict 2pt...

Irreversible processes far from equilibrium are then likely to locally generate structures, which P-S call "dissipative structures" DS, that is, a thermodynamically open system operating far from thermodynamic equilibrium, which exchanges energy, matter and information with the external environment. In this type of system, organization can emerge through a process of spontaneous self-organization, by virtue of exchanges with the external environment.

This concept reflects the association between the idea of order and the idea of waste: far from equilibrium, the dissipation (the "waste") of energy, at the microscopic scale, can be a source of new structures, that is to say of organization (of "orders") at the macroscopic scale, which is incompatible with the "disorder" postulated by the 2PT .

Without an external supply of energy (a not "powered" structure), mechanical movements eventually stop, and the temperature differences fade and cancel each other out. For the living, it is death.

However, a DS dissipates energy and therefore produces entropy that it evacuates as it produces it, but evacuating entropy also means importing

information. A DS constantly imports information from its environment. When it self-organizes, a DS (a cell, a man or a city) decreases its internal entropy, and therefore increases its information content by temporarily memorizing it.

The P-S 1959 model, by introducing the concept of DS, will provide a remarkably precise representation of the functioning of living organisms and societies. Prigogine will interpret the 2pt as follows:

$$dS = deS + diS$$

(dS variation of entropy; deS exchanged entropy; diS (irreversible) production of entropy) the second principle then becomes $diS \geq 0$ (Rodriguez 2017).

The typical example of a DS is the human species composed of living beings whose biological body is transformed at every moment. Man needs a regular supply of food (energy) to maintain the transformations and stay alive. The link between humanity and the 2PT remains because it conditions its existence. Same principle with societies, cities and nations: they constitute DS whose existence depends on the dissipation of an energy flow – an organizing flow – sufficiently large and stable.

In fact, P-S-1959 brings man back into history through the grand door of thermodynamics: The systematic form given to classical physics, its claim to constitute a closed, coherent, complete description of the world, expels man from the world it describes (P-S 1959 p 89)

This "*negentropic process*" (NP) is a measure of order and organization in a system, opposed to entropy which measures disorder. It represents the useful and structured energy available in a system to perform work, often used to describe the ability of an organism to maintain its internal order in the face of the increasing entropy of the universe.

The link between what will be called the NP and information theory was established by (Shannon 1949) who quantifies the value of information as the inverse of its probability of appearance and who defines its mathematical entropy as the uncertainty affecting its reception by an observer. In information theory, Shannon entropy is a mathematical function that corresponds to the amount of information provided by a source of information, whether it is a text written in a natural language, an electrical signal or any computer file (Rioul 2021).

However, Brillouin 1930 will make information a measurable physical quantity by merging the concepts of information entropy and thermodynamic entropy. He calls "negentropy" the amount of information that makes it possible to structure physical systems by evacuating their entropy. He rigorously makes the link between Shannon entropy (which was especially for the latter a mathematical definition) and the statistical entropy of Boltzmann, that of physics.

2.5. Three epistemological models of negentropy

The models proposed here represent the negentropic phenomena that nature imposes against the 2pt. They confirm certain conclusions of P-S and constitute as many epistemological models as possible because they show how to explain their behavior.

The first negentropic model is that of the economy, "*Since the economic process consists of the material point of view in the transformation of low entropy into high entropy, that is, into waste, and because this transformation is irrevocable, natural resources must necessarily represent a part of the notion of economic value.*" (G-R 1971 p 18) Furthermore, to evacuate man from thermodynamics has no solid basis, "since of all physical concepts, only those of thermodynamics have their roots in economic value and, consequently, could have absolutely no meaning for a non-anthropomorphic intellect" (Ibidem, p 277). In other words, the theories of P-S are found justified by means of the economy, as shown by the following model (G-R 1971 p 279).

Let's imagine a factory that transforms copper ore (with low entropy) into copper plates. For this, either men or machines are used, or both. Copper plates as a finished product, have more order than ore, therefore, in principle less entropy than the ore. Was entropy smuggled as some evil minds had imagined exchanging low entropy with high entropy to enrich themselves? Obviously not, because we only modified the molecules present in the copper as ores into molecules of the finished product in the plates.

Economics is not the "*philosopher's stone*" of the alchemists, because the free energy deployed (the power of labor and the energy of machines) in the process is irretrievably lost. So, like MD, it was necessary to use a greater quantity of free energy which is irretrievably lost. Any production process is an entropic waste because economic production only accelerates the process of perishing in nature. "*The conclusion is that, from the strict point of view of physics, the economic process is entropic: it neither creates nor consumes matter nor energy but only transforms a low entropy into a high entropy*". (G-R 1971 p 281)

G-R's main argument is that economic scarcity is rooted in physical reality and that all economic production does from a thermodynamic perspective is to irreversibly transform low entropy of nature into high entropy with more economic value through the flow of natural resources and human energy so that people can live.

Another model, taken from biology, is the "*amination*" of enzymes. That is, the addition of an "amine" group (organic compound derived from ammonia) in an organic molecule during a chemical reaction, by a substitution called nucleophile, that is, chemical species attracted by positively charged species. It is observed that when faced with two optical

isomers (molecules that are identical) and mixed in addition during the chemical reaction, fumaric acid exclusively catalyzes the formation of aspartic acid. "As a result, it provides information corresponding exactly to a binary choice" (Monod 1970 p 81). Like MD, the fumarase enzyme transforms low entropy into high entropy, but as Brillouin had proved the use of its cognitive system requires a certain energy consumption that compensates for the entropic reduction. Thus, the final balance of the operation sees the entropic decrease of the system (or negentropy) compensated on one side by an increase in the consumption of energy due to the universal principle according to which any acquisition of information supposes a consumption of energy (Monod 1970 pp 59-83)

The third model is that of the "*economic production of language*", that is to say the production of a sentence or statement with a minimum cost or effort. The choice of a word is made on the spoken chain (or syntagm) at the same time as, at the unconscious, one selects among several associative series (paradigms) in relation to the chosen syntagm. This discriminatory choice (analogous to that of the enzyme fumarase) creates an order in the production of speech, according to the idea that one wants to express. "In reality, the idea calls, not a form, but a whole latent system thanks to which one obtains the opposition necessary for the constitution of the sign" (de Saussure 1972 p 179). Thus, syntagmatic selection, whose objective is to limit the "arbitrariness" of the sign, introduces "a principle of order and regularity in certain parts of the mass of signs" (Ibidem p 82) by a teleonomic process (the "relatively motivated") which is an unconscious correction of the chaos of the natural system in the brain (the paradigms). Now, "relative" motivation uses the "most obvious" units of meaning, that is to say, those which carry more information (Ibidem p 181). It also consumes units with low entropy. Between these two poles (arbitrariness - motivation), the entire language system moves. The sign, like the matter of copper and like the life of the enzyme fumarase, must be transformed into latent energy.

Churchman will say that the sign has no suppositum because it depends on the desired information project, : "*The true benefit of an information system must be measured in terms of the meaning of information for the user*" (Churchman 1968 p. 112). It thus joins the functioning of (Gen-AI) as purely artificial languages. capable of generating new contents, ideas or data that imitate human creativity. But what about meaning? Perhaps the machine understands the meanings of words?...

We therefore note that any production system (economic, biological or linguistic) carries out the same unidirectional cybernetic process: a continuous transformation of low entropy into high entropy, with an irremediable loss in free energy.

2.6. How the three negentropic models are articulated

In the sense of the proposition, economic, biological and linguistic phenomena follow the same trajectory as Physics. How are they articulated to each another? What is then the epistemological difference between physical and economic phenomena and how the biological process is articulated to the economic process? Finally, what is the articulation between the economic process and the language process?

The answers to these questions are not trivial in the context of the relationship between (biological) man, his communication choices (internet, artificial language, Gen-IA, etc.) and the language of Economic Science.

Concerning the first question (the difference between the phenomena of physics and those of economics) lies in the fact that the physical entropic process is automatic (it continues by itself), while the second depends on the activity and oriented choices of humans. The economic process makes a sorting and, since it uses low entropy to transform it into high with the use of free (valueless) energy, it is more efficient than the mixing of nature itself.

As for the articulation between biological and economic processes: it was G-R who gave the answer: by merging the entropic process with the economy, G-R gave birth to bioeconomic, as a science of the economic management of the environment and limited resources, an economy integrated into the biosphere and whose biophysical foundations challenge traditional representations of the economy: "The bioeconomic program aims to contribute to maintaining the conditions of existence of humanity in a livable world through efforts to control entropic evolution [with] a reduction [...] of a materialistic attachment" (Ferrari 2024 p 6)

The articulation between biology, economics and language, it is (Levy-Strauss 1959 pp. 326-327.) who had noticed this relationship in primitive societies at the level of exchange; "In any society, communication takes place at least at three levels: communication of women, communication of goods and services, communication of messages. Consequently, the study of the kinship system, that of the economic system and that of the linguistic system offer certain analogies. "

We can thus perceive the relationship between the production of theories, on the one hand and the production of goods, on the other hand, that is to say, the relationship between a consciousness which produces systems of meaning and this same consciousness which produces goods of production.

We also see the similarity between these negentropic models and the root of social conflict in the economy and that of the conflict of theories: it is the appropriation of the exosomatic instruments. In economics, the creation of surplus has repercussions on social activity, and the distribution of wealth becomes the source of conflict. Since exosomatic instruments (capital) are no

longer part of the goods belonging to those who produce them, they thus become the basis of inequalities among societies and between nations. The distribution of income (goods and leisure) has become a conflictual social problem and contrary therefore to traditional Marxist though "will remain a knot of social conflict as long as there is any human society" (G-R 1971 p 102).

Contradiction between productive forces and social relations of production is not resolved by the simple collectivization of the means of production, because "The eternal root of social conflict over the distribution of income lies in the fact that our exosomatic evolution has transformed production into a social enterprise. It is clear that the socialization of the means of production will not be able to change this fact" (Ibidem).

The socio-legal contradiction has therefore been transformed into a bio-economic contradiction. As for information and its relationship with society, the production of exosomatic instruments such as scientific theories or instruments of new information technologies (software, algorithms, applications, AI, etc.), has also become a social production that is a source of conflict.

"Data" itself has become in the 21st century the exosomatic instrument whose appropriation is the core of the comparative advantages and competitiveness of companies and nations, thus becoming one of the most important issues of their sovereignty.

As for AI, as long as it reproduces writings of a language provided by human beings, it can be considered an exosomatic instrument in the same way as a machine. But, from the moment Gen-AI would be able to learn and to create languages and meanings, the question arises not only on the appropriation of the instrument between humans, but the more dangerous one of the appropriation (therefore source of conflict) between humans and the machine: «As Gen-AI becomes more sophisticated and it becomes increasingly difficult to distinguish between human-produced content and AI-produced content, opportunities and risks will continue to grow and merge, in compromises that require new ethical and legal frameworks" Floridi 2003 p 2

III. **Epistemology of Inquiring Systems and The AI**

The "Systems Approach" of Churchman 1968 (a); 1968 (b) and 1971) and his knowledge of epistemology has today become the pioneer in the field of artificial languages. Furthermore, his reformulation of the five approaches to epistemology became a major issue. With Leibniz, Locke, Kant, Hegel and Singer philosophy applied to what he called Inquiring Systems. (IS) *"Reason has become the subject of logic and logic has become the inventor of languages. Since languages are conventions, reason becomes the*

practical means of discussing and deducing [and]. performs the necessary but subordinate work of science, and we are all in a hurry to transfer its task to computers so that we no longer have to think about it" Churchman 1968 (a) p 39

3.1. Characteristics of cognitive systems

The quoted sentence from Churchman summarizes the goals that lead us to the development of intelligent software capable of becoming (as the founders of systems analysis had defined them) true "inquiring systems", research systems independent of human beings. How should epistemology move from human research and science founded by man towards an epistemology on the foundation of the knowledge of AI?

This path can only be done through language as an instrument of human and artificial intelligence. We will try to understand the start of this epistemological path from the concept of "cognitive system" (CS), the true "core" of our problem, of which the theory of systems has classified a part of the living "systems" ("the mind").

Epistemology thus becomes a description of the programs developed by the CS and a justification of their projects. The cognitive system therefore becomes an "*Inquiring System*" (IS) which can be a man or a machine.

In the teleological sense, the project of the IS determines the choice of an information domain. The perception of the relevant data will be done according to the requirements of the project and in the chosen language, for the transmission and processing of information. It is ultimately in relation to the chosen information language that the problem of efficiency (project-realization) will have to be posed.

The epistemology of IS is less interested in knowing how each system produces information than in knowing what the system considers as information, that is to say the "starting point" or emergence of the research, that is to say the operations themselves and the hypotheses which allow the decisions of choice. From this principle, the identification of the information units (the data) is part of this information, and these operations constitute the integral elements of an IS. (Mitroff. 1973) p. 256.

We can therefore consider that the problem of an IS capable of transmitting adequate information to the project is reduced to three aspects:

- (a) The criteria for choosing a purpose (visions).
- (b) The criteria for choosing a means of information (a language).
- (c) The units of measurement of this information (the data)

The epistemology of information must therefore answer three questions: What is the purpose of an IS? What is the structure of the AI language? What is the meaning of the expression of the IS? What are the units of measurement used in this language?

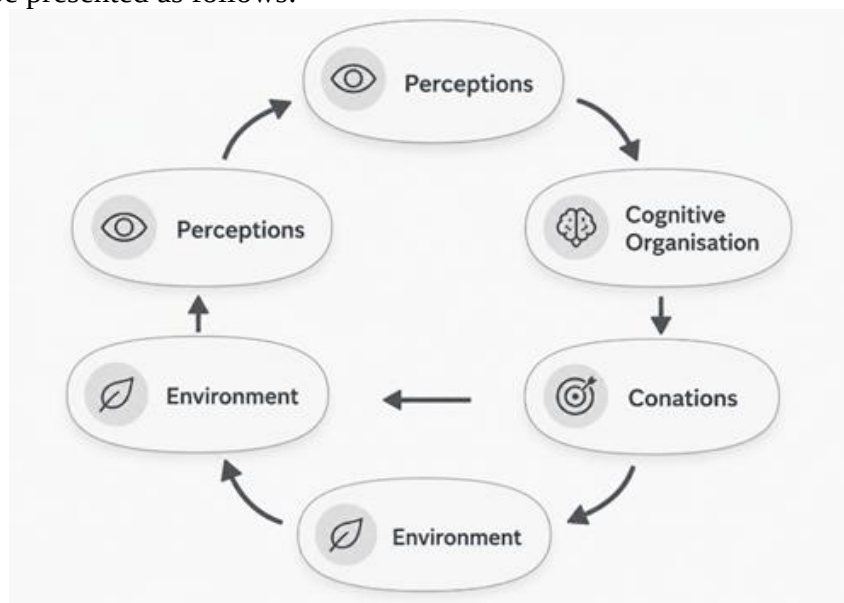
The first question is that of the "vision of the world" (weltanschauung) that the authors of an IS express through the system, the second is that of the structure of the language used, the third is that of the observable entities of this language.

3.2. Cybernetic systems and cognitive systems

Cybernetics, as defined by Wiener, had as a key element the notion of feedback to associate it with the object acting on its environment in order to achieve an objective. It is only one part of the analysis of systems, applied especially to the technology of self-regulated machines.

Cybernetic systems differentiate between "*cognitive systems*"(CS) as opposed to "*natural systems*", and (Laszlo, 1972 pp.18-19.) tried to elaborate the theory of such systems on the principle of "biperspectivisme". For him, between the external events that constitute natural systems (input) and those that form the human mind (sensation, memory, volition, etc.), there is an isomorphic relationship.

This means that the world (i.e. the set of observable phenomena) presents a structural uniformity, manifested by isomorphic traces of order in its different levels or domains. (Von Bertalanffy 1969 p87). These representations transfer valid, but not directly, information on the relations of the external world. Isomorphism would therefore allow us to know the invariant structures of the real world, devoid of individual categories, thanks to a homologous function. A CS is made up of a set of structures specific to any system, as we have described them previously. The dynamics of the CS can be presented as follows:



Graph 1.3: A physicalist type process

This diagram represents a physicalist type process where the notion of field is fundamental, perception is not done by association. but as a whole. It is Gestalt Psychology that was born in the last century as a reaction to behaviorism. Gestalt would therefore be a principle of dynamic, non-additive unity (the whole is greater than the sum of its parts), based on "psycho-physical isomorphism", defined in the following manner by one of its most illustrious defenders: "units of experience go hand in hand with functional units in basic physiological processes" (Kohler 1964 p65 and following)

The weak point of Gestalt Psychology was to consider the universe as complete and in stable equilibrium instead of seeing a progressive equilibration. Thus, from physical inspiration we moved to a biological type of conception. The theory of formation and that of games have also contributed to the overthrow of physicalism or rather to the observation of a "bipolarization" based on that existing in nature between reversible phenomena (mechanics and kinematics) and irreversible phenomena (thermodynamics)

For (Piaget 1970 pp 164-169) the operations of intelligence would be reversible phenomena (return to the starting point), while those of perception are not. This distinction is the dichotomous characteristic of CS and marks an epistemological limit between the AI and the human being capable of performing these two functions simultaneously.

When this CS is confronted with new experiences, it can use self-stabilization or self-organization. Or, both simultaneously. "The human mind tends to reestablish an internal organization composed of constructions (constructs) of specific types in specific relationships, when it is exposed to new models of perceptive experience" (Ibidem p 126).

This type of adaptation, almost dialectical, is represented in Figure 1.2 when the system has negative «feedback» (Figure C). In this case, part of the output (k) is used by the system to control the inputs (perceptions) so as to stabilize the stream of consciousness according to the current state of its organization. This is the function (S). "Therefore, a high-performance cognitive system can stabilize itself by means of this technique: it can create conditions in its environment that confirm and correspond to its existing cognitive organization (sets of constructs) (Laszlo 1972 p 128).

This is the role of the worldview or ideology that corresponds to the starting point of knowledge and theoretical propositions. Everyone builds around themselves the world that corresponds to their "weltanschauung", so as to be able to maintain the stability of their cognitive system.

Gen-IA does not have a worldview as a starting point, and it is tireless despite the accumulation of information to be processed (except for a greater consumption of energy by the machines). But is it free from any ideology? In the current state of their development since their "project", that

is to say its objectives are set by their creator, it is obvious that ideology is mixed with the language of machines through well-chosen concepts. Will it be the same when they are able to "create" their project as some hope?

In the field of scientific research (human IS), the self-stabilizing function of scientists directs the resistance to any change in established theories. (Kuhn 1970 pp 181-182) has shown extensively how scientists resist scientific revolutions in order to maintain a given structural organization: "the source of this resistance is the certainty that the old paradigm will finally succeed in solving all its problems, that nature will be able to fit into the box provided by the paradigm. (Kuhn 1970 p 209). The paradigm (and the invisible college) exercises a stabilizing β -type function that allows it to maintain its cognitive structure invariant subjected to new experiences by adequate control of inputs. This control introduces negative feedback.

The γ (or reorganization) function can have two objectives: either to correct dysfunctions introduced by the evolution of the environment in the β function (probably due to the entropy of the system), or to introduce a new positive feedback process: learning.

Learning is therefore considered in the epistemology of IS (therefore in all artificial cognitive systems) as a mutation while in organic systems it is a function of adaptation to the environment

This particularity of intelligent machines already identified by Churchman in the last century is a real risk for humans because it means that, in cognitive systems such as Gen-IA learning is a morphogenesis established by positive «feedback» of the system independently of the operator.

In other words, when AIs are able to learn, that is to say, not only able to reproduce the information received (the "what" or data received) but also when they have the ability to create this information (the "how"), even in a rudimentary way, they will undergo a mutation whose consequences for humans are unpredictable.

2024 is a date that will make history because research in the field of AI has just crossed this crucial step in the human-machine relationship. We know that artificial intelligence aims to mimic the functioning of the human brain, or at least its logic, but until now AI only reproduced the information that the operator provided it. However, Hopfield and. Hinton received the 2024 Nobel Prize "*for their fundamental discoveries and inventions that enable machine learning with artificial neural networks*" (Nobel Press Statement). Their pioneering work has provided a better understanding of how biological models of the brain can be used to solve complex computational problems. [they] "*have expanded our understanding of cognitive and perceptual processes, while paving the way for revolutionary developments in deep learning and artificial intelligence and machine*

learning technologies. [...], including image recognition, natural language processing and optimization of complex systems" (Academy OF Sciences Paris, October 8, 2024).

For Churchman, this cybernetic learning process should, however, respect certain hypotheses, in particular, learning is considered an exploration (a trial and error) consisting of trials and errors towards a "*state of equilibrium*", (which becomes an almost perfect imitation of the human brain), the answers are not only "*hic et nunc*" but also correspond both to a past experience and to an expectation of the future, In short, they are constructed historically. in cycles, with a temporal definition, etc. What implies an understanding of the meaning, which attests to the passage from a given moment to another later moment. This becoming is constituted as a succession of periods or stages in learning.

What about Gen-AI? Intelligent machines should allow a better forecast of inputs, that is to say a better knowledge of its environment, in order to have a better control of it: "The learning process results in the construction of increasingly functional maps of the relevant states of the environment, allowing a greater degree of predictability of future inputs. " (Laszlo 1972 p 131) Hence the need to permanently feed the Gen-AI with data from exchanges on the internet in order to increase its performance, therefore its knowledge.

A final question remains, however, unanswered: when the γ structure realizes (or will realize...) in the Gen-AI a mutation, does this lead to a greater organization (growth of knowledge) or does it only modify the organization of the system by a coherent manipulation of its language and the data received?

In other words, is learning in the cognitive systems of Gen-AI similar to the transformations of copper metal into plates, therefore without entropic change and simply by the transformation of the low entropy received in the information data, into high entropy (G-R 1971 p 277)? Or on the contrary should we rather conceive of this mutation as a new form of negentropy?

This question becomes all the more relevant as research on Gen-IA approaches the functioning of the human brain, as seen previously. The question can be asked in another way: we know that the process of human knowledge instead of creating entropy (following the principles of information theory by increasing knowledge) responds to the principles of a process exclusive to living beings: "*the living substance while not eluding the "laws of physics ... probably depends on "other physical laws" unknown until now", laws that he will then define as a "negative entropy"*" (Schrödinger (1944/1986 124).

However, do IS machines such as Gen-IA produce entropy (independently of the heat released by data centers) or are they assimilated to

the negentropic process? This problem cannot find a general solution because it certainly depends on the form that the emergence of knowledge takes in artificial language. For example, if Gen-IA works on the basis of neural networks, it is obvious that its operation creates entropy (unless we can prove that their learning process is negentropic). Now, if the Gen-IA only reproduces existing information with another combination (mathematical or simply linguistic) it is obvious that it does not produce entropy, and we are in the same model as that of the transformation of copper. The answer will also depend on the measurement of knowledge, that is to say on the forms of progress of knowledge and the type of science (progress in Physics is not at all the same as that in Economics).

The δ function, finally, of the IS presents itself under a double hierarchical aspect: an intra-system hierarchy e (which makes the system a whole in relation to its structures) and another inter-system, which constitutes it so that it is a part of another superior system (Laszlo, *oc.*, p. 134-138,).

3.3. Inquiring Systems and Artificial Language

How does Churchman go about articulating logic and epistemology with the IS, that is to say with the machine?

He will begin by defining five archetypes of the IS which are as many methods as possible of knowledge and great figures of Epistemology: Leibniz. Locke, Kant, Hegel and Singer (Churchman 1971). The two key concepts of his classification are the project (design) and the investigation (inquiry). In fact, the IS constitutes a subsystem of the CS defined by the GST: that is constituted of the structures where knowledge is active, because an IS is a processor (processor) that searches for symbols and data. According to him, the investigation ("inquiry") is an activity that produces a "collection of information", that is to say some knowledge for action.

Unlike science, IS are instruments for the development of knowledge. It is therefore an operational epistemology. In this sense, we can say that it is between a classical epistemology that ignores action (the why to do) and an epistemology of action that is wary of systematization. Because "conceptualizing or modeling a problem is to conduct an investigation into its nature, and conducting an investigation is to collect or to produce information about the nature of the problem. Thus, in this sense, "information is a function of epistemology" (Mitroff 1973, p. 125).

Now, since what we know depends on how we know, that is, since information depends on the research project in question, we must first specify what type of project we are talking about when we talk about IS. At the same time, the question arises about Gen-AI as IS: current algorithms generally ask for the goal, the objective of the information they can give us

(the project) and sometimes propose alternative solutions.

Will it be the same when Gen-AI is able to create this information (because it will have "learned" to construct the information) with objectives that will be specific to the machine? Will it be able to lie like human beings do in order to obtain a specific objective? Does machine language make sense of the information it provides? If so, how is the "machine meaning" articulated to its language?

3.4. Learning organizations and knowledge management

Currently, companies are trying at all costs to maintain their competitive advantage, particularly by acquiring data and information that allows them to remain competitive. This is why they are increasingly interested in the concept of "knowledge management". Because knowledge and information management are now a major asset for the competitiveness of companies, and they must manage them efficiently. This is one of the reasons that arouses their interest in setting up a knowledge management process.

It is in this sense that Churchman, with the concept of learning organizations, is deeply current concerning the search for information by the IS (the data) and becomes very close to what the AI and especially the Gen-AI (that is to say the operators) sometimes seek even illegality to feed its data banks. (This is the case with the large operators of clouds and other internet sites.)

When Churchman (1971, p. 18) reformulates the theories of knowledge of the philosophers cited, he transforms their languages "*into the language and design of research systems*", by providing "a description of how learning can be designed, and how the design can be justified" (Courtney et AL 2007 p 1).

The first point to be resolved in the functioning of the IS will therefore be that of the inputs (the data). Here, Churchman considers above all the control that the IS. can have on the data that is offered to it and that it perceives in one way or another.

It examines four possibilities, which correspond to four epistemological approaches typical of intelligent machines. Start with:

1. Elementary inputs that are clear and distinct, (Cartesian type).
2. Cartesian ideas that are not input (not relevant to the established research project.)
3. Unclear or poorly specified inputs.
4. Materials that are not inputs (not perceptible),

The choice of one or the other has inherent implications, either on the project (Locke's empiricism, admits only observable data), or on the form of the research (Kant's idealism, whose explanation can be contested by the

facts) or on the very nature of the materials. It is obvious that a material that is not a symbol cannot be processed by a machine. On the other hand, a symbol can be of different kinds of sentences, code, image, drawing, etc.... In short, anything that can be recorded, retrieved, transformed and grouped, "without reference to anything else" These IS were developed by his students in the form of models in 2007 (Courtney et AL 2007 pp 3-5):

Leibniz: a IS Leibnizian is a closed system with a set of embedded elementary axioms that are used with formal logic to generate formal networks or more general tautologies. Networks are created by identifying hypotheses, each new hypothesis serving to ensure that it can be derived from the basic axioms and that it is consistent with them.

Locke: These IS are experimental and consensual. Empirical information, gathered from external observations, is used inductively to construct a representation of the world. The elementary observations (the data) constitute the input to the Lockean IS which has a set of bases of labels (or properties: colors, shape, etc.) that it assigns to the inputs (the data).

Kant: The IS Kantian is a mixture of the Leibnizian and Lockean approaches because it contains both theoretical and empirical components. The empirical component can receive inputs, so that the system is open. It generates hypotheses based on the data received. Its particular characteristic is that the theoretical component can subject an input to different interpretations because the theoretical component maintains alternative models of the world (alternative weltanschauung).

Hegel: Hegelian IS operates on the premise that the conflict of ideas allows for greater enlightenment. The dialectic is composed of three actors, the first begins with a fundamental thesis constructed by a weltanschauung that makes the information, interpreted through this worldview, maximize support for the thesis. The second actor generates a conviction opposed to the initial thesis while the final actor is a "greater" mind that synthesizes a weltanschauung (greater).

Singer: Two fundamental premises guide these IS: the first establishes a system of measures that specifies the steps to follow to resolve disagreements between members of a community. (They can be transformed and compared eventually). The second guides the investigation of the IS and the strategy of agreement. In case of disagreement and the models fail to explain a phenomenon, new variables and laws are "swept" to provide advice and overcome inconsistencies.

This conception of epistemology opens new horizons in the field of knowledge and is closer to the knowledge of Gen-AI than to that of scientific theories, as seen in the style of learning.

How to distinguish in the epistemology of IS's whether a statement (or set of symbols) is "true" or "false" (regardless of whether it is scientific

or not)? Churchman proposes three constraints:

1. The IS. must be able to identify the origin of the statement (the interlocutor is known);
2. The IS. must ensure that this origin cannot produce "clear and distinct" statements that are false (credible interlocutor)
3. The IS. must have a code or very precise rules to establish its judgment (logical rules), which excludes a judgment independent of the machine

The problem is to first find an IS. that can meet these three conditions and from which other ISs can be constructed. It is necessary to find the source of perception and the guarantee of its adequacy to reality (Descartes' "cogito ergo sum"), but with precise and well-established rules. However, (Churchman 1971 pp 79-94) rejects the Cartesian method for his basic epistemological model for reasons that seem doubtful to us in his interpretation of Descartes. He would prefer the method of Leibniz. Why?

Because the method of Leibniz, although not using "clear and distinct" ideas, has the advantage of being formal and of using the rules of logic. It is therefore operational, "and only requires analyzing the form of the proposed sentences" Following very precise rules, the Leibnizian "processor" determines the truth or falsity of a sentence. set of any well-constructed statement. It is a comfortable epistemology because, even if its relationship to reality is not assured, its analytical character allows the exploration of new concepts. It will be the basic method of the IS.

How do these IS work then? The starting point or emergence of the system is not external. Perceptions are created from within the IS (the monad). These perceptions create a stream of consciousness through imagination. The main question is to be able to identify the significant sentences. Which can be done if this stream is conceptualized symbolically according to certain rules designated as "well-formed functions" (wff)!.

Once again, the modernity of Churchman and his epistemology are perfectly articulated with what science has been looking for since the critique of scientific language: propositions endowed with meaning, therefore with hermeneutics. The first step will therefore be to specify which of the wff are tautological (they do not provide real information) or contradictory (they go against logical rules) in order to eliminate them. Then he defines the conditions of a Leibniz-type IS in six functions

1. Innate ideas (therefore no "external" inputs at the start).
2. Production of symbols that can be cut (into phrases) that are discernible/measurable.
3. Possibility of classifying the wff into tautological and non-tautological classes.
4. Possibility of forming significant units through relations and certain

(logical) operators constructed or not by the system itself.

5. Possibility of arranging these units according to a criterion determined by the operator.
6. Existence of a predefined method based on the arrangements to process the symbols and build the significant units and an optimal significant unit or to converge towards this optimum.

Finally, the Leibnizian research system has all the qualities of formal systems: consistency, rigor, logical coherence, precision, etc... Its defects are also the same: subjective (choice of innate ideas, for example) and empty of experience content (purely analytical). Its best possibilities of use are found in the type of well-structured problems.

The Leibnizian IS (Ibidem p 83) needs an executive body that can exert a direct influence on the senseless proliferation of contingent truth networks or sets of tautologies... without any kind of control. In our digital civilization it is the role devoted to AI to carry out this control on the data obtained by Cloud software and the extraction of data from the Internet network, sometimes without the knowledge of the users.

3.5. The IS between rationalism and empiricism

At the opposite extreme of Leibniz and the rational method we find the IS of Locke (Churchman 1971 pp95-127), that is to say the empiricist method. The starting point here will be the pure data of perception (the inputs) and the problem will be to be able to guarantee that a simple sensation or a sign is really relevant information. The rule to be applied will be "social", a "community of minds" that wants to collectively agree to a type of response to environmental stimuli.

The function of human judgment should accomplish the transformation of raw data into factual information because the machine seemed, according to Churchman, incapable of differentiating data from information (as AI algorithms currently do). How then can we determine according to Churchman that an input is a "simple sensation" (observable), so that the group can admit it?

The feeling must be "labeled", marked. (For example, labels such as "red", "acid" etc. But how can a label be accepted if the criteria of its relevance are divergent? How can the same unit of measurement be accepted when the criteria diverge, for example the measurement of economic value (price, marginal utility, labor force, etc.?)

Apart from the epistemological solution of the choices made by a machine, conflicts of opinion regarding science must be resolved by the group (or society) in order to agree on these criteria. Therefore, the inquiry into the simplicity of the IS is a community inquiry with a common vision and a common language: More than one person is therefore needed,

otherwise the criterion would be arbitrary, and we would fall into Leibniz's innateness

We can present a Locke type IS on the following assumptions:

- a) Conflicts are easily resolved by the machine.
- b) There is a finite set of X inputs: $x_1, x_2, \dots, x_n$
- c) There is a finite set of Y's of labels, $y_1, y_2, \dots, y_n$ (i.e. different sorting of inputs).
- d) There is a finite set of Z outputs of each IS, $z_1, z_2, \dots, z_k$ •
- e) There is an operator external to the IS C, consisting of more than one person.

This IS operates according to 11 rules defined by (Churchman Ibidem pp 126-127). Churchman, however, recognized that the difficulties of such IS. were numerous. At his time, he was far from imagining an AI capable, for example, of resolving conflicts and comparing them. However, the "simple" sensations of the Locke system are only possible through a strong generalization and a mode of representation, through which the facts are elaborated by the imagination...

In addition, for a system to be teleological, a constraint must be introduced: the decision-maker (the operator or the machine) must be able to rank the different alternatives in an order of efficiency (which will depend on his system of values or the utility that the action brings him), in this case, we can speak of individual utility as a finalized utility

There is also an even deeper problem, that of the group consensus beyond empirical data. For scientific epistemology, the consensus around a theory is the paradigm of Kuhn, that is to say, the set of beliefs of a "normal" science, not recognized in their theories...Finally, we have the IS of Leibniz which poses the problem of control on the production of "forms", while that of Locke poses it on the "consensus" around the empirical data.

The epistemological choice leads us to the methodological dilemma between a criterion of logical truth and a criterion of empirical validity, in other words between two visions which confront each other, at the antipodes of each other by their ideological positioning, their methods of investigation and quantitative analysis. Here we are sent back to the insoluble conflict and controversies between the rationalism of Popper and the empiricism of Carnap, a debate which will spread over the last half of the last century until today! Will AI be likely to generate another form of research for scientific truth?

IV. The Dynamics OF Inquiring Systems (IS)

The epistemology of research systems imagined by the Churchman team would like to overcome the curse of enigmas in classical epistemology. But it does not succeed. However, this convergence towards the same

concerns is not in itself a step backwards from any horizon of progress

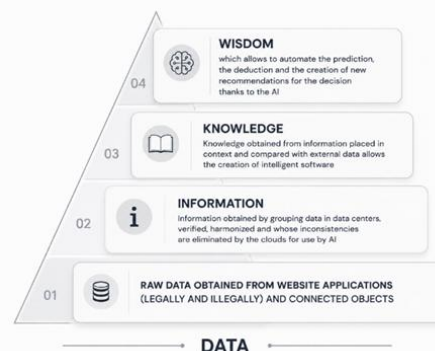
On the contrary, epistemology, as a search for scientific truth, is always enriched and revealed in its diversity of forms. Creator (man) and creature (machine) yesterday as today find themselves in a kind of eternal recommencement between creator and creature... In this circular flow, there is a hidden desire for identification that would allow the creator, through his creature, to grasp his own meaning, or at least his limits. But the more perfect the creature is, the more elusive the creator becomes, through his intelligence and imagination. Whether it was yesterday with Churchman's IS or today with AI, when these machines start to work, we can first ask ourselves why and how do they work?

Why do they work in one direction and not the other? Who really controls their operation and how can we ensure that its teleonomy (its objectives) are consistent with the objectives of their creator? etc.4.1 Ackoff's pyramid and IS

Ackoff 1973 had prophetically declared about information in organizations: *"I believe that we are leaving one cultural and technological era to enter another. We are at the beginning of a change in our conception of the world, The sociotechnical revolution we have entered could well be known as the Resurrection. (Ackoff 1973 p 661). Ackoff's modernity is found above all in its pyramid known by the acronym DIKW, used mainly for business management and represented on four levels:*



Graph 1.4: The Ackoff's DIKW



Graph 1.5: DIKW can easily be reconstructed with the instruments of the 21st century

In the current context of the development of AI, "data" has become a fundamental element in the enrichment of Clouds and other databases in order to enable the development of the cognitive capacities of Intelligences created by machines.

4.2 Data as a key element of the Comparative Advantages of Nations (ACN)

The exponential development in our century of Clouds and connected services on the digital market have given DIKW an obvious relevance.

Comparative advantage is today a fundamental parameter for the survival of European companies in a context of globalization and imperfect competition, particularly in the digital market where information and economic data become the essential issue. It is also through comparative advantage that interest groups and alliances between nations are formed.

The first economic paradigm to have reflected on the economic advantages of nations was the mercantilist paradigm born after the discoveries of the New World and the need for free trade between nations. These commercial exchanges will give rise to a form of thought that will gradually become an economic doctrine: the "mercantilist paradigm". (Heckscher 1962). This paradigm is built around a major postulate: gold is the wealth of nations, exports bring gold to nations, so the role of the State is limited to protecting exports to maintain the competitiveness of the nation and its comparative advantage.

With the ideas of Smith (1723-1790), economic thought appeared as a true doctrine of the Absolute Advantage of Nations (Aan). Concerning this, Smith advises "never try to make at home what will cost less to buy than to manufacture". This is the theory of absolute advantage.

The postulate of absolute advantage will be perfected by Ricardo (1772-1823) who will defend the principle of the Relative Comparative Advantage of Nation (RCAN): a country has an interest in specializing in the production of goods for which it has a comparative advantage, in terms of (relative) production costs and productivity. Corollary of this postulate proposed by Ricardo: each country must specialize in the production of a good for which it has a greater abundance of the factors necessary to produce this good.

Heckscher and Ohlin (1991) proposed a mathematical theorem to prove Ricardo's theory on RCAN. The H-O-S theorem (the S for Samuelson corrections) seeks to demonstrate that each country produces and exports the product for which its main factor of production is the most abundant (relatively) because the product that requires this factor of production is (relatively) cheaper.

Porter (1980) developed the concept of Advantage Competitive of Nations (ACN) built on five pillars: the intensity of competition, the bargaining power of customers and suppliers, the threat of new market entrants or the threat of substitute products. (Porter 1990) Recently (following the emergence of the digital revolution), he has significantly modified his conception of the ACN. According to his new theory,

companies, whatever their sector, will have to compete by offering objects connected to digital platforms and linked to the internet network, so they will have to constantly review their development strategy.)

Porter thus conceptualizes the revolution of connected objects: the third great wave transfigures the strategy and competition already introduced by information technologies around the 1980s.

It then places information at the very heart of the product (and no longer only at the market level) and transforms the product itself as well as, by ricochet, the value chain, modifying the terms of competition and restructuring the markets.

Porter thus changes its defensive vision of the competitive market, towards a more offensive approach where companies must constantly question their strategy. Because companies operating in this digital market where data is becoming a key issue for competitiveness, will try to make informational relationships "asymmetric" in order to create a comparative advantage thanks to the information obtained from their competitors.

What was once the source of comparative advantages of nations is fading away in the searches for information to feed the AI of large groups. New elements are introduced by what is called the data economy, which are disrupting traditional theories of economics on competitive advantage.

Data, as a raw material, is present everywhere and anyone can produce it. This considerably reduces the importance of the monopolies of raw materials that have conditioned the economy and civility over the last few centuries. Secondly, the price of data-centric products is not proportional to the cost, but to the value perceived by the customer. (Wagner, 2020, p. 121).

Therefore, the quality of the product or service is not necessarily proportional to the quality and cost of the hardware adopted, but rather to the experience and usage of the end user. Third, data production is done on data platforms, which require that most of the cost's development is invested at the outset, and not proportionally to the income generated.

4.3. Information and economic theories

Economists have built their theories in the shadow of the model of "pure and perfect competition" of (Walras 1896), whose essential characteristic was the perfect knowledge of market conditions by economic agents and the "homogeneity" of products. The connectivity of highly diversified "intelligent" products has completely destroyed the Walrasian hypotheses.

The first elements of information theory applied to "the class of teleological systems" (with a precise purpose such as economic organizations) were the works of (Churchman 1971) that we analyzed

previously. What is the scope of information in economics? And how is information introduced into economic thought and theories?

The key concept is that of "*information asymmetry*", developed by Stiglitz 2003, that is to say when one of the economic agents has more information on the characteristics of the market than another and uses it to obtain a competitive advantage. This asymmetry is crucial when it comes to risks in the decisions of a particular company or simply in economic policy decisions. A fortiori in the field of innovation and the country's business strategy.

But information, by its intrinsic qualities, also presents certain difficulties in its use in economics, because it is a collective good by its properties of indivisibility and *inappropriability* and can be used by several economic actors at the same time. This raises, among other things, the problem of intellectual property and information ethics (Floridi 2023)

Information also has a price and sometimes its cost can become an obstacle for the company (in particular information on the interconnection characteristics of an innovative product). Large groups also have other means of obtaining this type of information at zero cost...

V. The Natural Language And the Gen-AI

5.1. The Generative Transformational Grammar (GTG)

"The empiricists of scientific language were locked into the purely syntagmatic aspect of language. This "a priori" did not allow them to escape their epistemological contradictions". (Katz 1963 p23). The linguistics of the end of the 20th century will include two currents: that of the defenders of an artificial language based on intelligent machines that we have analyzed, Churchman and that which considered language as an expression of human nature (Chomsky1969) and its *Generative Grammar* (GG) capable of solving the problems posed by epistemology. (Katz- Fodor, 1963 p 6).

Generative Transformational Grammar (GTG) is an approach to the use of grammar in communications that involves a logical and analytical process to fully grasp the meaning behind the selected words. From this point of view, it goes beyond the process of structural grammar (such as that developed by de Saussure), which tends to focus on the proper construction of sentences as a tool of communication.

In addition to the structure of sentences, GTG will also attempt to explore the thinking behind the words and apply logic to the task of searching for the deeper meanings of sentence structure and analyzing both the surface and the underlying intention of the words used. This type of grammar draws on most of the tools of linguistics to attempt to fully analyze the spoken or written word in the utterance. It is for this reason that Gtg is concerned with epistemology.

Chomsky finds in Descartes (as does Churchman ...) the foundations of the creative aspect of man in the production of language, that is to say his capacity to emit new statements from a given grammatical set. (Chomsky 1969 p 18) This creativity of language is achieved by a sort of combinatory of the meanings of complex units (syntagmatic and paradigmatic) by operations of amalgamation or mixing of the pre-existing meanings in the human mind. It is manifested in the competence of the speaker, that is to say in *"the capacity that the ideal speaker-listener has to associate sound and meaning in strict accordance with the rules of his language"* (Chomsky 1969 pp 56-57).

These "rules" are the syntactic and semantic rules that are part of the grammar of his language. The speaker's competence is actualized in his performance, that is, through the set of *"extralinguistic considerations concerning the speaker and the situation"* (Ibidem). In other words, the speaker's performance (the perfection of a sentence) includes his competence in his own language, plus the (extralinguistic) context at the time of the utterance.

GG thus becomes a device that allows us to specify the correct statements of the language. We can represent a "perception model" (PM) *"as a device that accepts a signal (or phenomenon perceived among many other pieces of information) as input and assigns various grammatical representations as output"* (Ibidem p 127). For Katz, performance (of discourse) must consider other factors that enter into the production of the speech, including that of linguistic competence. Consequently, the theory of (natural) language is part of epistemology, that is, the articulation between words and the object of a sentence, while a discourse analysis will have to be deeply psychological (Katz 1932 pp 116-118) because it must consider the context.

The epistemological difference between GG and Gen-AI is that the first includes in the performance of language aspects other than linguistic (mental reality), while the second is only a pure discourse: a language whose components are the elements of all languages.

We therefore have, according to Chomsky, at the syntactic level a visible syntagmatic structure that can be interpreted phonologically and that can vary from one language to another. *"On the other hand, 'the deep structure, which expresses the meaning is - it is claimed - common to all languages, because it is only the reflection of the forms of thought' the 'meanings' or 'semantic traits' are not directly related to meaning in the surface structure"* (Ibidem).

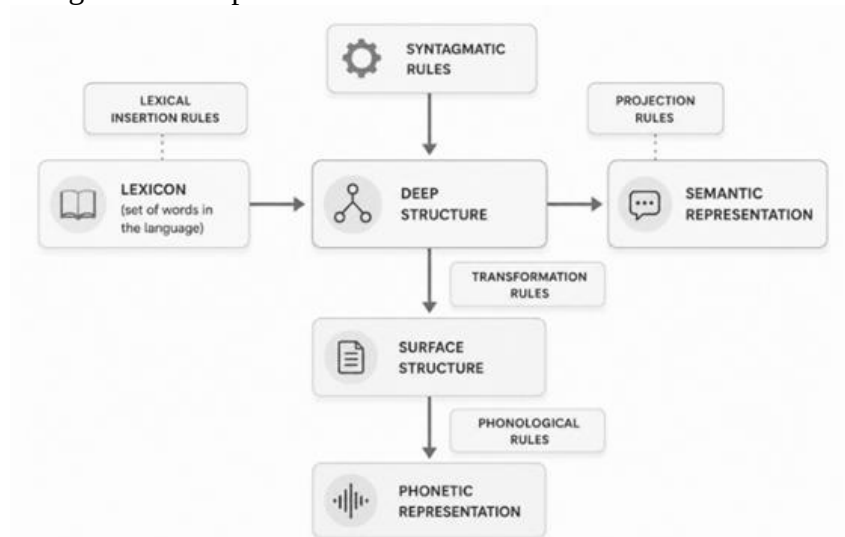
The *deep structure* also includes the transformation rules that allow, from the syntagmatic indicators of elementary sentences, the creation of syntagmatic indicators of complex sentences. As far as AI is concerned, it is

obvious that we cannot speak of a "deep structure", which limits the "competence" as a generator of new discourses (including contextual information) so also AI is limited in its "performance ».

This theory of language assumes having reached three adequacies: the observation of phenomena, their description and their explanation, for each component of grammar (syntactic, phonetic and semantic) (Chomsky 1970 p 63).

At the syntactic level, however, since it is obtained by the description of deep syntagmatic structures and not only by the surface structure, but they also participate in the understanding of an utterance and consequently they are of interest to epistemology. Consequently, the understanding of the syntax of a speech in a natural language (including that used by AI) should integrate the three adequacies cited. The description at the semantic level of the observed phenomenon is carried out through a dictionary (or the machine memory) of the language used, so as to constitute "semantic fields" on which projection rules are applied that show the process by which the speaker uses his knowledge of the dictionary to construct meaningful sentences.

The following graph shows the different rules that Chomsky (1984) attributes to the speaker/listener in the formation of a speech from the syntagmatic rules (of the language in question) that will determine the functioning of the "deep structure".



Graph 1.6: Different rules that Chomsky (1984) attributes to the speaker

Let us emphasize that at the start of the deep structure, the rules of the semantic component apply in particular, which calculate the meaning of the sentence from the information in the dictionary and from the information given by the grammatical description of the sentence.

In other words, the projection rules, which come from the deep structure (therefore from human nature) "generate" in the speaker/listener of the natural language, the meaning of the words defined in the dictionary of the language. *"According to the principle of projection, at each level of syntactic representation, a subject and an object must be present in the appropriate structural configuration"* (Chomsky (1984) p 16.)

Therefore, the constituent units of the deep structure must allow the interpretation of the meaning of statements and sentences: *"on the basis of his knowledge of the grammatical properties and the meanings of the morphemes of the language, he decides which parts of the sentence are composed in such a way as to form a whole."* (Katz/Fodor 1963, p 171). The meaning is given by the semantic indicators ("*semantic markers*") which express the semantic relations and allow determining the true meaning to be given to a unit and the meaning of a complete sentence thanks to the rules of projection.

If we now compare the performance of the human speaker with the performance of a machine that automatically applies a dictionary stored in its memory to a proposed sentence by associating each morpheme in the sentence with its dictionary entry (which is what Gen-AI does, for example). The machine will not be able to select the meaning(s) that the morpheme carries in a given sentence context, except in the case where the selection in the dictionary offers a defined meaning or a choice of meanings for the morpheme used in the sentence. (Ibidem p 182).

The problem for a machine is that a dictionary generally provides more meanings for a lexical item than it contains in a given sentence, because a dictionary entry is a characterization of all the meanings that a sentence or phrase can contain. Therefore, the role of the projection rules should be to select the appropriate meaning of each lexical item in a sentence in order to provide the correct distinct interpretations of that sentence.

In summary, Chomsky will say: *"Universal Grammar... is a hypothetical component of the genetic heritage, in the same way as the properties which make the embryo have arms rather than wings, which make it use the principle of rigidity, which make it go through puberty, etc.... Once we adopt this change of perspective, this part of linguistics enters into psychology and, ultimately, into biology."* (Chomsky (1984, p 21)

5.2. Semiotics: the third dimension of language

Bolinger 1967 p 448 noted that a semantic theory should not only show the semantic features of a word but also predict possible changes in order for it to have the status of a true theory. Katz will say that these indicators are only "hypotheses" or non-observable entities, like the micro entities and microprocesses used in quantum physics: *"The linguist can no*

more look inside the speaker's head than a physicist can directly observe photons" (Katz 1966 p 182) So, these are indeed hypotheses that cannot be empirically refuted but which, like exact sciences, allow the explanation of phenomena linguistics related to it and possibly predictions. In reality, the problem with Katz semantics lies in the fact that a dictionary (or the memory of an AI), if it completed as it may be, can never include all the interpretations of the meaning of a statement.

This is the third dimension of language, *semiotics*, already highlighted by Frege (1892) in his well-known example of "*the evening star*" and "*the morning star*": these two statements "denote" the same star, but their meanings are different because they "connote" two different thoughts and only the denotation can have a truth value. (Carnap 1947 p 26)

A sentence or a sentence should not only be developed in its syntagmatic and paradigmatic dimension, but also in its semiotic dimension, which seems impossible for Gen-AI.:*"Any linguistic act supposes to travel the linguistic space in its three dimensions. It will have to travel the semiotic axis going from the meaning to the text. For each element of meaning, he will have to select a linguistic sign and therefore go through the paradigmatic axis of the choices available to him. Finally, he will have to consume the entire meaning he wants to express and therefore go through the syntagmatic axis by combining the chosen linguistic signs, thus producing words one after the other, that is to say a text. »* (Kahane 2015 p 45)

VI. Epistemology OF The Digital Economy (ED)

We discussed in the previous analysis how the economic system is transforming and adapting to innovations and technical progress until the Gen-AI. This "metamorphosis" of the economic system, however, introduces new "epistemological obstacles" (Bachelard (1938), for the theories and its explanation of the economic reality. We will try to give at least a partial answer to all these questions that present themselves as epistemological enigmas in the new "digital economy" (DE)

6.1. New challenges for the economist in the DE

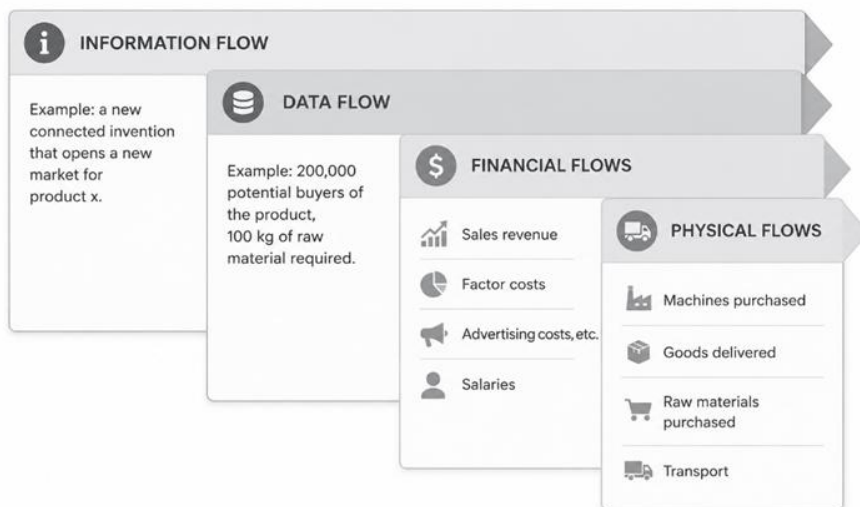
At the dawn of the 21st century, capitalism is leading a third industrial revolution, the digital or cybernetic revolution, based on new non-physical factors: information, connectivity and artificial intelligence. The new capitalism of the DE is characterized by the search for exorbitant profits with lower costs. We can see a path of paradigm shifts, from the Industrial Economy (IE) that appeared in the Industrial Revolution and the Financial Economy (FE) that emerged after World War II when industrial capitalism metamorphoses from an economy of tangible capital and goods (machines)

to an economy of intangible (capital money).

Then the change of this financial capitalism towards a digital capitalism (DE) with the ability to build goods and services enriched by data (purely intangible economy).

The growth of the intangible economy is an obvious fact, and the proof is easy to find in the famous S&P 500 index, where in 40 years we have gone from having more than 90% representing the IE (industrial companies) to the opposite situation now with more than 90% made up of the ED (products or services based on information and therefore data). The equation is therefore simple: 90% of the flow of the "real" economy is a data economy, that is to say a flow of information that translates into a system of economic values.

But this equation leads to an apparent paradox: if the ED is both "*intangible*" (by the flow of information) and "*real*" (by the flow of data), then we have a correspondence between the value (prices) of the information economy (intangible) and that of the real economy (data), but which is fundamentally disconnected from what was previously considered the real economy (physical). Graphically:



Graph 1.7: Relations between physical flows and the information flows

We can explain these phenomena by considering the data economy induced by the digital revolution, not as a financial economy, but as a new form of industrial economy, a mutation of the capitalist system where the raw material is data and where machines and the factory are replaced, or integrated, by data sources, data connectivity, data computation, data storage, algorithms, AI, APIs, etc.).

In this evolution from the old IE to the new data-driven economy of the digital industry (DE), there are however substantial key differentiators. One of them is evident in the accessibility of the raw material (data), and the other in the business model and revenue stream behind digital products. Data in fact, unlike any other raw material, is everywhere, mostly free, infinitely recyclable and self-regenerating. As data is everywhere and self-regenerating.

Therefore, many economic concepts developed by theorists on tangible economic values, for example production costs (marginal costs, average costs, etc.) based in particular on the (physical) law of diminishing returns, completely collapse. The equilibrium of the firm and the maximization of profits based on the same law with increasing marginal costs in the short term are then "empty concepts" or "empty boxes" like those of the controversy at the beginning of the last century. Here are some examples:

The margins and profits of the firm are no longer proportional to the cost of labor and the cost of materials, but mainly to the value perceived by the customer and the proof is already visible on the market where a "smart" product has a higher price compared to its non-smart equivalent, purely determined by the analysis of the competition and not by the production costs.

Furthermore, the industrialization cycle is different in the new ED. Platforms, the aggregate of the technology stack and the components needed to provide a data-driven service, are in fact the engine of the data economy but they must be fully implemented, operational and ready to evolve on the market before even starting to sell the first service (This is the aaS business model: as a Service).

Concepts like Roi (*Return of Investments*), to calculate the break-even point of a product and justify investments before starting its development, are not applicable in the new world of the data economy and digital products: either we "try and fail quickly" or we "follow and die"!

These epistemological changes impose a new way of considering the data economy and the concepts of economic theories, both in the production of digital products and services, financial analysis, economists, and politicians, who must understand and predict trends and strategic decisions to drive the future of the world.

6.2. The source of profit in the new digital economy

The source of these profits in the ED is no longer found in the workforce of a country or in international financial markets, but in the interconnectivity of a multitude of economic agents, regardless of their place of action or their economic space.

The new "*economic agents*", in the era of "data capitalism", can be identified in the concept of "platforms". According to Pareto's law, we could say that more than 80% of the global data economy is driven by a handful of data platforms that are now dominant on the market.

However, unlike the EI and EF models the commercialization of data (or data monetization) has not yet reached the level of maturity of the raw material in the industrial revolution or of international financial assets. The reason lies fundamentally in the difficulty of calculating the value that can be produced from a specific data set, and therefore of assigning it a price and income, and therefore a distribution among the factors of production (which ones?). It is the market demand that will determine the pricing model, in a typical path from freemium to premium determined by market adoption and the proof of the perceived value of information and data.

6.3. Artificial Intelligence (AI): A New Agent on the ED Chessboard

With the emergence of AI, a new phenomenon has been added to ED: machines capable of replacing humans in the cognitive part, and not only in the executive part. In addition to the difficulties, we have mentioned above, this raises another question about the new data economy: will it be an evolution under human control or the first manifestation of a self-autonomous technology (capable of learning to create information and not only to process it (as we have seen in Churchman's research) that will determine the future of our economy and, ultimately, the evolution of human beings?

With the advent of AI, an aspect of technology that was often overlooked by many has become obvious and malleable to all: technology can replace humans and ignore their rules.

The recipe for AI is nothing more than a combination of cognitive algorithms, data ubiquity, near-real-time connectivity, and exponential computing power, which makes a machine finally capable of not only automating what a human does, but also predicting options, autonomously deciding to operate, replacing the human in the decision to execute, and ultimately replacing the human in the creative process of inventing and designing something.

If we consider the economic side of the world, this means that decisions made by entrepreneurs, investors, managers, politicians, will potentially be replaced, or even seamlessly intertwined, with decisions made by a synthetic version of their ego and their projects. It is impossible to know to what extent this will help or influence decisions, as well as the final effects of such a revolution in the absence of clear transparency and control mechanisms to build the necessary (still intangible) barriers.

The famous concept of man-machine interface (MMI) is replaced by the many possible permutations of man/machine/other machine interactions, etc. Already, in the many types of agents in an economy it is clear that many of them are already under partial or total governance by automatons (chat-bots, server robots, guests, neural networks, etc.) that make decisions on their behalf. This introduces a new problem, even worse than AI ethics: who and how is the governance of M2M engagement and interaction done?

6.4. The VA of Artificial Intelligence and Data in ED

So, how will the added value generated by AI and in general by interconnected objects be defined and integrated into the GDP of nations?

Value is not generated by technology, but enabled by technology, whether AI or others. Therefore, we can think of an induced value that the availability of data produces. Let's try to categorize in simple terms the type of data that can be associated with a product or service. Data can be:

- a) internal to the product (e.g. a car brake equipped with sensors to monitor the brake.); or
- b) external to the product or service (e.g. an air pollution sensor); or
- c) by correlation and algorithms (such as reporting low fuel and finding gas station)
- d) personal (i.e. properties captured or produced by the user) and
- e) machine data (property of or produced by the device, or software),

The d and e distinctions lead to an observation: most of the data that concerns an individual or a company, ends up being derived directly or indirectly from personal data (e.g., the smart mobility applications sector would not make sense without personal geolocation and route tracking). Then there is enterprise data, which is intellectual property under the control of a company (e.g. data collected from the sensors of a car fleet that becomes personal data).

Data quality is a combination of: Resolution, Precision, Frequency (so that for example, a parking lot with a traffic light on each floor of the parking lot, not connected to each other, and turning green as soon as a car leaves the floor, is better than a single traffic light on the entire parking lot).

Another characteristic is the format of the data. Applying a contextual data model, or data schema, that provides both structured data (e.g., a table) and unstructured data (e.g., media files), under a context-specific taxonomy (e.g., a list of key currency pairs by country) and in a machine-readable form, will have a higher value than raw data that cannot be understood.

Finally, the biggest contributor to the value of the data economy is probably provided by data transformation, which are the algorithms transforming data into derived data that can produce a perceived value for end users. (For the same fuel, a more efficient engine will be offered, with

more power and that consumes the same amount of fuel).

With AI in the world of algorithms, autonomous driving now introduces in the world of cars a big change: in normal driving, the driver controls the car, while in autonomous driving, it is the car that controls the driver. Thus, with the advent of AI, technology can take control of human beings.

Trying to summarize it all, one could imagine a model where the value of the data is a function of all the attributes described above, given each value and a multiplier factor.

6.5. What are the measurement units for the VA of companies?

In generic terms, the measures of success of a company will remain the same: cost, revenue, margins. The new data economy, as explained above, foresees new paradigms that allow higher margins, less dependence on traditional fluctuating costs subject to external factors such as political crises and inflation, less dependence on raw materials and geographically agnostic value chains.

On the other hand, it will be necessary to make larger initial and ongoing investments to be competitive in the new market, and to have fewer predictive tools such as return on investment. The identification of Fcs (Key Success Factors, i.e. the critical skills within a company that allow it to achieve its objectives and competitiveness), BD (*Business Development*) and KPIs (*Key Performance Indicators*) is necessary therefore, it requires a different effort than in the past. The time to market a digital product is faster, usually less than 6 months, and the break-even point is usually 3 to 5 years and proportional to the reach of the product (the larger the market reach, the longer the break-even point because it will depend on all its customers).

Each organization will be free to set different goals and measure them against different indicators, but to support this analysis, it is useful to consider some particularities of the data economy that can help to measure more accurately the real success and added value of a company operating in the new ED.

First of all, ED is driven by digital technology, which in itself can be compared to steam or electricity in IE but the key difference is that digital also considers the human cognitive part of the work, while machines and energy fundamentally replace the physical part of it.

The more cognitive it is, the more autonomous it is, the more intelligent it is, the more value it will produce. But also, the greater the risks of control and governance and the fear of users will be. Thus, providing evidence of the level of automation and cognitive algorithms, but also of the methods to ensure transparency and controllability (trust) on them, will be an element of value, to be measured and exposed to the market.

A second key factor is that data, the equivalent of raw materials in the traditional economy, cannot be measured, verified and certified as in the work of tangible goods (due to the lack, as yet, of common standards). Data quality is therefore a much more complex and less standardized measure to obtain and its description of the quality of data uses (as described above) will be a distinctive element to classify the added value of a business product, or of the business itself.

A third key factor is that in the economy of intangibles there are no physical depreciation of any kind, while in the economy of tangible goods, physical limits (obsolescence) determine the capacity, scalability, cost and profitability of any business.

How to measure the comparative advantages of companies and multinationals in this interconnected market?

On the one hand, the data economy requires moving from a disjointed data model to a federated data model, which involves bringing together several companies to jointly create common value (products, services, improvement of production processes, etc.), but at the same time, the distribution of returns is a key factor in building a federated environment that maintains the necessary trust between the parties. The difficulty with digital is that there are no standardized ways to show the boundary between where data is produced, processed and transformed into a final product or service that the user adopts, and therefore the final supplier of the product cannot estimate the contribution of all the actors in the value chain.

Conclusions

We started this study with the intention of laying the foundations of an epistemology of new knowledge techniques, in particular artificial intelligence and the language systems attached to it. The overall objective of this essay would be to find:

- i. The field of knowledge of AI
 - ii. The approach method (deductive/inductive)
 - iii. The method of validation of hypotheses (confirmation/corroborator)
 - iv. The analysis of the languages used
 - v. The logical coherence of its propositions (syntactic and semantic)
 - vi. The appropriation of the meaning of the propositions (semiotics)
- I. Concerning the field of knowledge, the evolution of the IS designed by Churchman towards the AI which is developing in the 21st century, this field has been considerably expanded, but we discover a common input in both visions: data as a fundamental unit of information and for the development of their language.
 - II. In the approach method, Churchman's IS are dependent on the two

classical approaches (Locke's inductivist empiricism and Leibniz's deductivist rationalism). The algorithms of the AI language try to overcome this double epistemological antinomy by a "methodological pragmatism (MP)" which adapts well to user demands. This MP corresponds perfectly to the "digital discourse" of AI, obviously freed from ideological "a priori" and any constraints linked to the more or less scientific properties of its statements.

- III. The validation of hypotheses. AI as it currently stands would be incapable of developing a hypothesis, much less having the capacity to evaluate it. Indeed, a hypothesis requires a theoretical framework with well-defined "correspondence rules" between the hypothesis and the facts to be verified. Furthermore, the concepts of "truth"/"falsity", "confirmation/refutation" assume verification criteria that are limited, in the current state of Gen-AI, to those received from their creators and to the manipulation of the data it receives, far from the power to imagine a hypothesis.
- IV. Today Gen-AI is fundamentally a language, an algorithm that can answer the problems and puzzles submitted to it with the speed of a machine and the perfection of an artificial language. Its speech precisely respects the rules of syntax and can store in its memory the information that corresponds to the semantic content of this syntax, according to a dictionary that feeds on the information received permanently.
- V. If we consider the constraints and characteristics of the (IS) with the five epistemological models, it is obvious that they respect a logical coherence in relation to the five classical methodologies suggested by Churchman. Does the Gen-AI respect this coherence in the propositions of its language? The answer is in the propositions that the Gen-AI can offer and in its further development. Let us simply recall that the logical coherence of the propositions (syntactic and semantic) of a language, according to Chomsky, does not depend on the "deep structure" but simply on the rules that the creator of the AI will set beforehand
- VI. As far as semiotics are concerned, it is difficult to conceive of any competence of artificial language in the domain of meaning. The "deep structure" according to Chomsky is the privilege of human nature (Lakoff 1986). *"The game of language is the game of the world. To grasp the world, one must get out of it, and to get out of the world, one must get out of language. But it is through language that we can get out of language"* (Ladriere 1970)

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