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A General Rationale for Scientific
Model-Building

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SCIENTIFIC MODEL BUILDING:
PRINCIPLES, METHODS AND HISTORY

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Page

1. INTRODUCTION

In the history of philosophy of science we can identify three mainstreams of thought in the quest to provide the foundation of scientific knowledge. They can be recognized by the names of empiricism, idealism, and theoretic empiricism. The corresponding approaches to model building are already suggested by their respective names. The latter, i.e. theoretic empiricism, is the only sound philosophy of science capable to account for a given aspect of reality and to provide a meaningful explanation of it, which leads to the specification of scientific models with increasing explanatory power and having the potential for relevant applied work. As a consequence, under appropriate structural constraints, scientific models are powerful constructions to be used for predictions and decisionmaking.

The theoretic empiricism philosophy of science can be cogently illustrated using Wold's (1969) models for knowledge. It subsumes in a unified and coherent structure the three main inputs to the process of scientific model building as a relevant scientific enterprise, i.e. factual observations, ideas, and the use of reason to elaborate upon the ideas germane to and evolving from initial observations. Therefore, the empiricist and rationalist (idealist) philosophies of science have their places as parts in a coherent whole.

The purpose of this study is to discuss the philosophy of science approaches to scientific model building and Wold's models for knowledge, illustrating them with some historical examples from several domains of the factual and methodological sciences, and to present a program of scientific research in economics. This program is integrated with one essential characteristic of economics as a science for action, i.e. the policy implication of economic knowledge.

The content of this research is organized as follows: Section 2 presents a classification of scientific knowledge; Section 3 deals with three main philosophy of science approaches to scientific model building; Section 4 presents Wold's models for knowledge; Sections 5 and 6 deal with economics as a science, discussing its properties and a program of scientific research, and its relationship to Lakatos' methodology of scientific research programs; Section 7 presents some historical cases of theoretic empiricism in science; and Section 8 concludes this study.

2. PHILOSOPHY AND SCIENTIFIC KNOWLEDGE

Wold (1984) observed that up to "the early medieval universities, philosophy was a catch-all science". There about, specialized knowledge, such as physics and astronomy, started to acquire scientific autonomy. These discipline's secessions from philosophy have continued in time as soon as a new autonomous scientific knowledge was built. Such are the cases of chemistry, biology, economics and sociology. This sequence of secessions prompted some philosophers to specify their field as a residual. In this context, Munz (1982, p. 1235) states: "Plato and Aristotle wrote about morals and physics, about mathematics and politics, about literature, cosmology and psychology. In our century, every one of these topics has become the subject matter of a special discipline. People who call themselves philosophers in the 20th century are mostly people who deal with the residual problems -that is, with those problems with which Plato and Aristotle also dealt, minus all the important fields of knowledge which have since become the subject of special sciences."

Without literally subscribing to Munz's comment, we should observe that the main problem of philosophy seems to be its own object of knowledge, which is much too ambitious to be successfully dealt with by the human intellect. It is concerned with first causes and ultimate foundation, and its level of aspiration is to deal with reality as a whole. Therefrom, the following essential properties of philosophy emerge:

i) totality of theme (pantonomia);

ii) autonomy of mode (autonomia).

From these properties, it becomes apparent the success of the specialized discipline steming out of philosophy, and the so far impotence of the human intellect to successfully deal with its subject matter. However, within the "residual problem" remain specialized fields of knowledge such as epistemology, philosophy of science and logic which are the subject matter of intensive inquiry and systematic development.

At the risk of raising an unnecessary polemic, let us present in Table 1 a classification of knowledge, including an incomplete presentation of the "residual problem", i.e. the third group in Table 1.

TABLE 1

Classification of Scientific Knowledge

1. Factual sciences (substance of knowledge)	Natural sciences:	matter as object of knowledge
	Biological sciences:	life as object of knowledge
	Social sciences:	society as object of knowledge
2. Methodological sciences (form of knowledge)	Mathematics Logic Statistics	
3. Metaform of knowledge	Methodology Epistemology Philosophy of science	

The factual or empirical sciences deal with an aspect of reality. The material reality (nature), life, and society are the object of knowledge for the natural, biological, and social sciences, respectively. To the latter belong economics and sociology. Economics secessioned from philosophy in the later 18th and early 19th centuries, as the result of the contributions by F. Quesnay, A. Smith, T. Malthus and A. Cournot, and sociology in the 19th century, mainly due to A. Comte's contributions.

The factual sciences are concerned with the substance of knowledge, whereas the methodological sciences are concerned with the form of knowledge; the metaform of knowledge deals with the procedures by which new substantive knowledge is acquired by a knower, and with the validation and assessment of the body of scientific knowledge. In synthesis, it deals with the methodology leading to the specification, validation and evaluation of scientific research programs.

3. TYPES OF APPROACHES TO MODEL BUILDING

Three main approaches can be identified as the sources of ideas leading to a theoretic construction, and they recognize their origins in the contributions of the Greek philosophers. They are,

i) the empiricism (Democritus);

ii) the idealism (Plato);

iii) the theoretic empiricism (Aristotle).

i) The empirical approach can be traced to Democritus, a follower of Thales, who maintained that the senses allow the mind to apprehend the truth by means of the factual observation of the corresponding aspect of reality. For him, ideas and knowledge recognize the sense as their unique source. With Bacon, Locke and Condillac, Democritus's approach is revived. They maintained an empirical sensationalism based on the principle that observations made by sense perception are the foundation for human knowledge. Condillac objected Locke's tenet that the senses provide intuitive knowledge and contributed to a further polarization of this one-sided approach by asserting that all human knowledge is transformed sensation. This philosophical approach can also include the 19th century German historical school of economics. Because of its very narrow empirical foundation and rejection of the appropriate use of a sound mathematical methodology, this school missed the historic opportunity to being the founder of the modern and powerful econometric methods in economic inquiry, which belongs to the theoretic empirical approach. Instead, it became the forerunner of a descriptive mode of quantitative inquiry, which characterizes the content of economic statistics.

ii) The idealist approach can be traced to Plato, followed by Descartes, Kant, Hegel and von Schelling, and in economics, by Leon Walras, the founder of the Lausanne school of mathematical economics and one of the founders of the neoclassical school of economics. This approach neglects the role of experience and maintain that knowledge is an a priori intellectual construction aimed at providing a logical structure capable of describing the observed events. For the philosophers embracing this philosophy of science approach, the mind perceives the truth through reason, i.e. the intelligence in action, without the control of factual events. The most elaborated development of idealism is found in Hegel. He asserted that what is rational is real and what is real is rational. In economics, Walras adopted a similar doctrine, which seems also to be the tenet of today neoclassical economist in their interpretation and use of Muth's (1961) seminal contribution on rational expectation.

iii) The theoretic empiricism takes the positive and one-sided contributions of both empiricists and idealists, to advance a relevant and conclusive approach to scientific discoveries. This approach is associated to Aristotle and in the Middle Ages to Saint Thomas Aquinas. In the first half of the 20th century, Ortega y Gasset went beyond the pure reason dominant philosophy and developed his principle of the historical reason, which rigorously belongs to the theoretico-empirical approach. Among the most distinguished economists and econometricians adopting this philosophy of science approach, we should include Adam Smith, Malthus, Ricardo, Marx, Pareto, Keynes, Schumpeter, Frisch, Tinbergen and Wold. Herman Wold's models for knowledge is an evident testimony of the meaning and relevance of the theoretico-empirical approach to scientific model building.

In the context of the philosophy of science approaches to model building, two types of intelllects can be distinguished: the passive one, which receives the facts from the senses without adding on further elaboration, and the active intellect, which goes beyond the factual observation to elaborate them with the help of a set of initial and imaginative (working) hypotheses. The senses receive the information (signals) of an aspect of reality and stimulate in the mind the generation of ideas; information and ideas are elaborated by reason, as the intelligence in action, which provides a general, rational theoretic explanation. That is, the intellect has the power to generalize, going beyond the narrow bounds of sensations. In this content, Saint Thomas Aquinas wrote (Part 1, Question 1, Art. 9), "we are of the kind to reach the world of intelligence through the world of sense, since all our knowledge takes its rise from sensation." Then he illustrated his viewpoint with an interesting example. He observed that a triangle is first perceived by the senses which stimulate the observer ideas, and the intellect will be able to pass from the observed triangle to the theoretical concept of the triangularity. Mutatis mutandis, we can think of the earliest time of civilization whereby a man counted his possessions and thus he got the idea of a set of numbers, passing afterward to (generalizing) the theoretical concept of the set of positive integers. Following this empirico-theoretical process we could achieve a logical reconstruction of the set of real numbers, complex numbers and vector space. It was the necessity to account for the existence of $\sqrt{2}$ in the directed straightline as the point of length equal to the hypothenuse of the isosceles triangle OAB (Fig. 1) that lead to the bijective relation between the set of

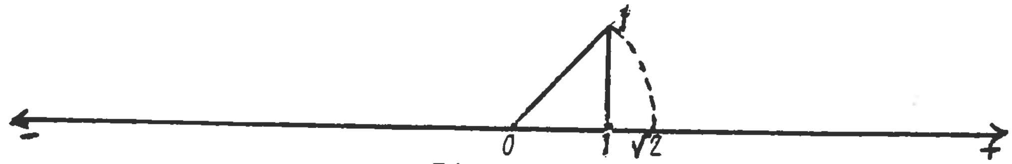


Fig. 1

real numbers and the set of points in the directed straightline. It was the observation of birds flying in the space that stimulated the idea of conceiving a device to allow human beings to fly, and therefrom to the theoretical development of the flying machine mechanics initiated by Leonardo da Vinci and Jean Bernouilli. These are instances of the intellect's capacity and power to generalize.

Theoretical empiricism represents a harmonic integration between observation-sensation and reason, within a given frame of reference, leading to model specifications possessing the properties of rigor, relevance and realism. Thus, it integrates both the empiricism and the idealism within a coherent whole as a rigorous, relevant and realistic approach to scientific model building.

Although Kant's contributions belong to the idealist philosophical school, he wrote a revealing paragraph, which clearly describes the sequence sensations-ideas-reason. He stated

(Kant, 1787, p. 14) "that all our knowledge begins with experience there can be no doubt (...). In respect of time, therefore, no knowledge of ours is antecedent to experience, but begins with it. But, though all our knowledge begins with experience it by no means follows that all arises out of experience." Consequently, if we start from scratch, or seeing things in the light wherein the source is not to be found in the fact, methods and results of the preexisting state of the science, our knowledge begins with experience. When we start our own research from the work of our predecessors, that is, from the scientific heritage of civilization, our knowledge is the joint outcome of ideas and reason, whereby reason elaborates and develops the new ideas into a more ambitious and powerful abstract knowledge.

Hence, theoretic empiricism is a cogent synthesis of the following age-old and vitally important three worlds (Lakatos, Vol. 1, 1978, p. 119): "the first world is that of matter, the second the world of feeling, beliefs, consciousness, the third the world of objective knowledge, articulated in propositions." This trichotomy is clearly in the Aristotelico-Saint Thomas Aquinas approach. Leading contemporary proponents are Popper (1972, Chapters 3 and 4) and Wold (1969).

It follows from Table 1 and the theoretico-empirical philosophy of science that the first world is that of matter, life and society, according to the scientist object of inquiry; the second, the world of intuitions, ideas, consciousness and working hypotheses; the third, the world of reason leading to objective knowledge, articulated in propositions. It is the synthesis of a dialectical process between the first two worlds, within a given frame of reference (circumstance, purpose, truthlikeness and standards).

Therefore, theoretical empiricism possesses the property of being ontological and epistemological realist. By asserting that there exists an external world - whose objects of knowledge are matter, life and society - even though we could not be able to make observations, it is ontological realist. It is epistemological realist because it maintains that the function of scientific methodology is to find out properties of this external world. Nikolaas Tinbergen (1974) stressed the importance of openminded observation of "watching and wondering", which is in perfect harmony with Saint Thomas Aquinas sequence of observations-ideas-reason, and as such belongs to the theoretico-empirical approach.

The idealism is ontological realist and epistemological idealist since it does not deny the existence of an external world but asserts that the model representation of this external world is a scientist's mental construction carried out with the purpose of providing himself with a convenient instrument to be used to accomplish objectives such as description and prediction of events.

Volmer (1984) cogently objected to the coexistence of ontological realism and epistemological idealism. He stated that "ontology is prior to epistemology, and both ontology and epistemology are prior to methodology. That is, ontological statements have epistemological consequences, and both ontology and epistemology have methodological consequences (...). Holding a realistic ontology, we must - in order to avoid inconsistencies - transfer our realism to epistemology and methodology. The converse is not true. From a successful methodology, we may not cogently infer that our underlying ontology and epistemology are correct."

Several independently formulated philosophical and methodological comments and discussions can be conceived as implicit criticisms of the instrumentalist philosophy of science, such as Aristotle's "transition to another kind" (μετάβασις εἰς ἄλλο γενος), Yule's spurious correlations, and some econometricians' criticisms of regression without theory, i.e. according to Yule's terminology, spurious regression. Gilbert Ryles, a mid-20th century English analytical philosopher, introduced the concept of category mistakes, which is indeed Aristotle's transition to another kind. Its meaning is that, if a form or entity belonging to one category is substituted into a statement in place of one belonging to another, a nonsensical assertion must result.

An extreme form of idealism is solipsism, which could be characterized as being both ontological and epistemological idealist, since it maintains that, for any scientist, only his mind and his sensations exist.

To the idealism, and <u>a fortiori</u> to the solipsism approach of scientific model building it could be rightly applied Kierkegaard's assessment of Hegel's system, who regarded it as a luxurious palace of ideas, wonderfully built, endowed with great aesthetic and logical values, but without the least existential value.

4. WOLD'S MODELS FOR KNOWLEDGE

The factual sciences build their theories and models from the observation of reality. The unknown theoretic structure object of inquiry provides incomplete information (signals) of its essential nature which defines a sample realization of its functioning. The signals (the empirical domain E) and the unknown structure (the theoretical domain T) give rise to a matching process (Wold, 1969) between theory and observation, which leads to a model specification M as a formal theoretic representation of T. In the Aristotelico-Saint Thomas Aquinas approach, M is the outcome of the observations-ideas-reason sequence, whereby, observation and ideas correspond to Tinbergen's watching and wondering. Wold (1969, p. 431) formalized it (Fig. 2) as models for knowledge. It is a representation of a dialectical process between E and T, within a specified frame of reference, whereby each synthesis is a model specification of T (Dagum, 1977, 1979).

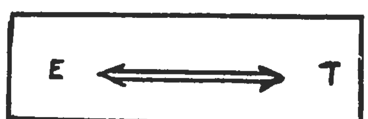


Fig. 2

Kuhn's (1962) structure of scientific revolutions leading to paradigm constructions and paradigm changes can also be seen as a dialectical process. It can be summarized in the following six steps (Dagum, 1977, 1979):

1) "normal" science evolving from an accepted paradigm;
2) small unexplained phenomena which orthodox researchers are confident can be fitted in;

3) stretching the theory in an effort to fit unexplained phenomena;
4) period of confusion;
5) period of innovation and opposition;
6) "normal" science again, <u>qua</u> synthesis of the former five steps.

In Wold's models for knowledge (Fig. 2), the dialectical process between E and T, and the frame of reference enrich the first three steps in Kuhn's structure of scientific revolutions. They lead to a sequence M_1, M_2, ..., M_h of model specifications, within a common frame of reference, whereby each M_i satisfies a higher level of aspiration, i.e. a higher level of rigor, relevance and realism than the former specified models. This is the situation when "stretching" the theory achieves the purpose of fitting unexplained phenomena. A case in point could be a sequence of Keynesian's models of income determination, such that all of them recognize Keynes' (1936, p. 246-7) frame of reference, hence Keynes' paradigm, which includes, (i) his fundamental analytic categories such as, the propensity to consume, the attitude to liquidity and the expectation of future yield from capital-assets; (ii) the wage-unit as determined by the bargains reached between employers and employed, and (iii) the quantity of money as determined by the action of the central bank. A more elementary example is given by the alternative Keynesian consumption function specifications, such as the absolute, relative, permanent and life cycle hypothesis.[1]

Wold's frame of reference is illustrated by the rectangle in Fig. 2. It represents the primitive ideas, the design and purpose of the model to be specified, which determine the researcher's level of aspiration, truthlikeness and standards, and the environment or circumstance[2] that conditions T and the signals E generated by T. In economics, the "national structures", and in an open economy we should add the "international structures relevant to a given national economy", contribute to spell out the circumstance. By national structures we mean the economic, social and political structures, and the socio-economic infrastructure. The economic structures are mainly integrated by the structures of production (technology), distribution (institutions) and exchange (the economic units's objective functionals, and the institutions regulating the market structure, which determine the economic units' modes of action and interaction).

In the context of the spirit of the laws, Montesquieu (1748) advanced an illuminating statement which is relevant to both Wold's frame of reference and the concept of national structures. He wrote (T. II, p. 238), that the laws "must be relative to the physiognomy of the country; to its climate, i.e., burning or temperate; (...) to the religions of its inhabitants, to their inclinations, to their wealth, to their number, to their trade, to their customs, to their manners. Finally, they are related to each other (...). I shall examine these relationships: together they constitute what one calls the spirit of the laws."

Taking into account the substance of Montesquieu's statement, we could replace the last sentence by saying that "together they constitute what one calls the national structures", since Montesquieu's <u>esprit des lois</u> is a structural concept.

Wold (1984.a) observed that A. Comte, in the second quarter of the 19th century, and E. Mach in the fourth quarter of the same century introduced the systematic coordination of T and E as a methodology for scientific inquiry. The former used the term "positivism" and the latter the German term "bild" (i.e. picture), and both were misunderstood. Karl Pearson, at the turn of the 19th century, introduced the goodness-of-fit statistical test to assess the closeness of M to T by means of M and E, whereby E is treated as a sample realization of T.

5. PROPERTIES OF ECONOMICS AS A SCIENCE

Economics belongs to the social sciences. Hence, according to Table 1 it is a factual science. As a social science, its aspect of reality is defined by the economic unit specific activities of production, distribution and exchange within an organized society (circumstance) and conditioned by it. The markets are the immediate institutional structures within which the economic units activities take place and evolve. However, it should be stressed that there are not markets without society, and there is not society without power. This fundamental statement underlines the basic interdisciplinary relationship of economics with both sociology and political science, and brings to the fore the role of power in the functioning of an economic system.

Some of the most relevant properties of economics as a science are:

i) factual or empirical;

ii) non-experimental;

iii) ontological;

iv) evolutionary;

v) historicity;

vi) teleological;

vii) ideological.

Thom (1975, p. 1) stated that "whatever is the ultimate nature of reality (assuming that this expression has meaning), it is indisputable that our universe is not chaos. We perceive beings, objects, things to which we give names. These beings or things are forms or structures endowed with a degree of stability; they take up some part of space and last for some period of time."

This paragraph underlines several of the properties listed above. The very name of science attached to economics is a statement of existence of stable regularities whose coherent representation takes the form of models. Since our economic universe is not a chaos, it is a well defined object of knowledge, hence there is a place for and a role to be played by economics as a science.

The economic reality object of inquiry could be thought of as an unknown stochastic structure to be identified. This unknown stochastic structure corresponds to the theoretical domain T (Fig. 2), and the economic agents' performance and interaction within T induce the generation of a set of signals, factual information, which belong to the empirical domain E. These signals are the raw material to be elaborated by an appropriate use of the methodology of science to arrive at the specification of a model M qua inference of the unknown stochastic structure T. For this, we have to follow the theoretical empiricism path, i.e. obsrvations-ideas-reason-scientific model. In this context, twenty five centuries ago, Heraclitus advanced the cogent statement that the lord whose oracle is at Delphi neither speaks nor conceals, but gives signs. That is, by means of Delphi's oracle, Heraclitus' lord provides the empirical domain qua sample realization of an unknown theoretical structure T. This sample realization stimulates the scientist ideas, and the ensuing application of reason leads to the identification or inference of T. In economics, the signals come under the form of prices, output, income, consumption, investment, employment and others.

Economics, and in general the social sciences, are factual and non-experimental sciences, for social sciences phenomena can not be replicated.

Researchers in the experimental sciences can replicate the outcome of the phenomena which is the object of their inquiry, as it is the case in important domains of physics, chemistry and biology; they can recreate the physico-chemical, and biological morphology. Therefore, these are factual and experimental sciences. Other disciplines are factual and non-experimental because of spatial distance (astronomy), temporal distance (history, geology, paleontology), or behavioral and institutional irreplicability (economics, sociology). For the latter, it should be observed that the <u>object</u> is also the <u>subject</u> of knowledge, and because of that the subject can be able to assimilate theories and experience to justify a change of decision when faced with the same set of circumstances. That is, the subject can absorb a theory or rationalize the circumstance of an experiment, or an empirical outcome, leading to the re-assessment of the responses. Morgenstern (1972) dealt with this characteristic in the field of economics and called it absorption theory.

An "experiment" in the social sciences certainly is not a constant replication of the circumstances under which a controlled variable is steered (entering as an input), and a specified effect is observed as an output. The so called "experiment" in the social sciences are nothing more than simulations, where very often a teacher makes the "social experimental design" and his students play the roles corresponding to the specific social agents retained performances. The students circumstances, psychology, motivation and risks, when playing in a classroom, for example, stock market simulation, cannot be construed as a replication of real stock market investors. Should we accept Borel's (1937) theorem that the human mind cannot imitate chance, which is universally accepted and is at the very base of the construction of the random numbers tables, then we should <u>a fortiori</u> accept that a human mind cannot replicate other human mind rationality.

As a factual science, economics searches for a coherent explanation of an aspect of reality. It is achieved when a meaningful economic structure is identified as the generator of signals and offered as an answer to the question "what is". This characterizes the ontological dimension of economics, which is also a property common to all the factual sciences.

The properties of evolution and historicity present some degrees of overlaping. Thom's quotation given above, that the "beings or things are forms or structures endowed with a degree of stability; they take up some part of space and last for some period of time", clearly stresses the property of evolution of the forms or structures, hence they are historically parameterized. In economics, the acceptance of this property implies that it has no structural stability. What is its time horizon? Unlike important domains of the natural sciences which present a structural stability for millions of years, and the biological sciences with a structural stability lasting for thousands of years, in the second half of the 20th century, an economic structure takes up some part of space and last for some period of time which is often shorter than the life span of a generation of human beings.

Historicity underlines the economic agents memory variables which enter as inputs to the decisionmakers, and are specific to the social sciences active units.

Unlike the natural and biological sciences, the dominant dimension of the economic units is not "nature", it is history. As Ortega y Gasset (1947, T. VI, p. 182) cogently wrote, "history is not only seeing; it is thinking what has been seen. And in one sense or another, thinking is always contruction". This statement contains the important sequence by which we characterize the theoretical empiricisms, i.e. observations-ideas-reason-scientific model.

The economic units do not have only memory variables (historicity); they have also project variables, purposeful aims or final causes, revealed by means of implicitly or explicitly specified objective functionals to be optimized. This underscores the teleological dimension of economics, which is not a property of the natural sciences, whereas in the biological sciences it was the subject matter of a heated polemic.

The explanation of an aspect of the economic reality with the incorporation of the memory and project (planned and expected) variables were the subject matter of important modelization such as partial adjustment, adaptive expectations, and rational expectations. They contain expected and/or planned variables which are non-observables and where Wold's (1980, 1982, and with Joreskog eds., 1982) soft modeling methodology can be fruitfully applied.

Palomba (1981, 1984) provides a rigorous and stimulating analysis of time and economics, motivating it by means of several illuminating quotations. They underline the role of history and expectations in economic theorizing. One of them is by Saint Augustine who wrote (Palomba, 1984, p. 32): "three are the times, the pass, the present and the future; however, it could be said: three are the times, the present of the pass, the present of the present, and the present of the future. Although they are already in our mind, we can see them from another perspective: the present of the pass is the memory, the present of the present is the direct representation of a given reality, and the present of the future is the expectation."

Ideology has a dual role in the social sciences, ergo in economics. There are circumstances in which ideology and social philosophy enter, by their own nature, as inherent realities in a program of economic research. In other cases, they are sources of bias, impairing and damaging the whole content of a research program. O. Lange (1964, p. 524) stated, "all social sciences are in some way connected with the major ideological trends which form social consciousness in modern societies." Then he added (p. 525), "ideological influences do not always lead to the apologetic degeneration of social science. Under certain conditions, they may be a stimulus of true objective research. The aspiration for social justice, progress and welfare generally stimulate scientific research because true knowledge is needed in order to successfully control social processes," i.e. true knowledge is needed to make the best decisions.

6. PROGRAM FOR A METHODOLOGY OF ECONOMIC RESEARCH

The teleological property of economics and the roles of the project variables emphasize economics as a science for action. These specific aspects are integrated in the following six steps of a program for a methodology of economic research (Dagum, 1977, 1979):

1) specification of a field of research;
2) model specification of the observed structure;
3) estimation of the theoretic structure;
4) specification of a target structure;
5) testing the null hypothesis between the estimated theoretic structure and the specified target structure;
6) specification of a decision model.

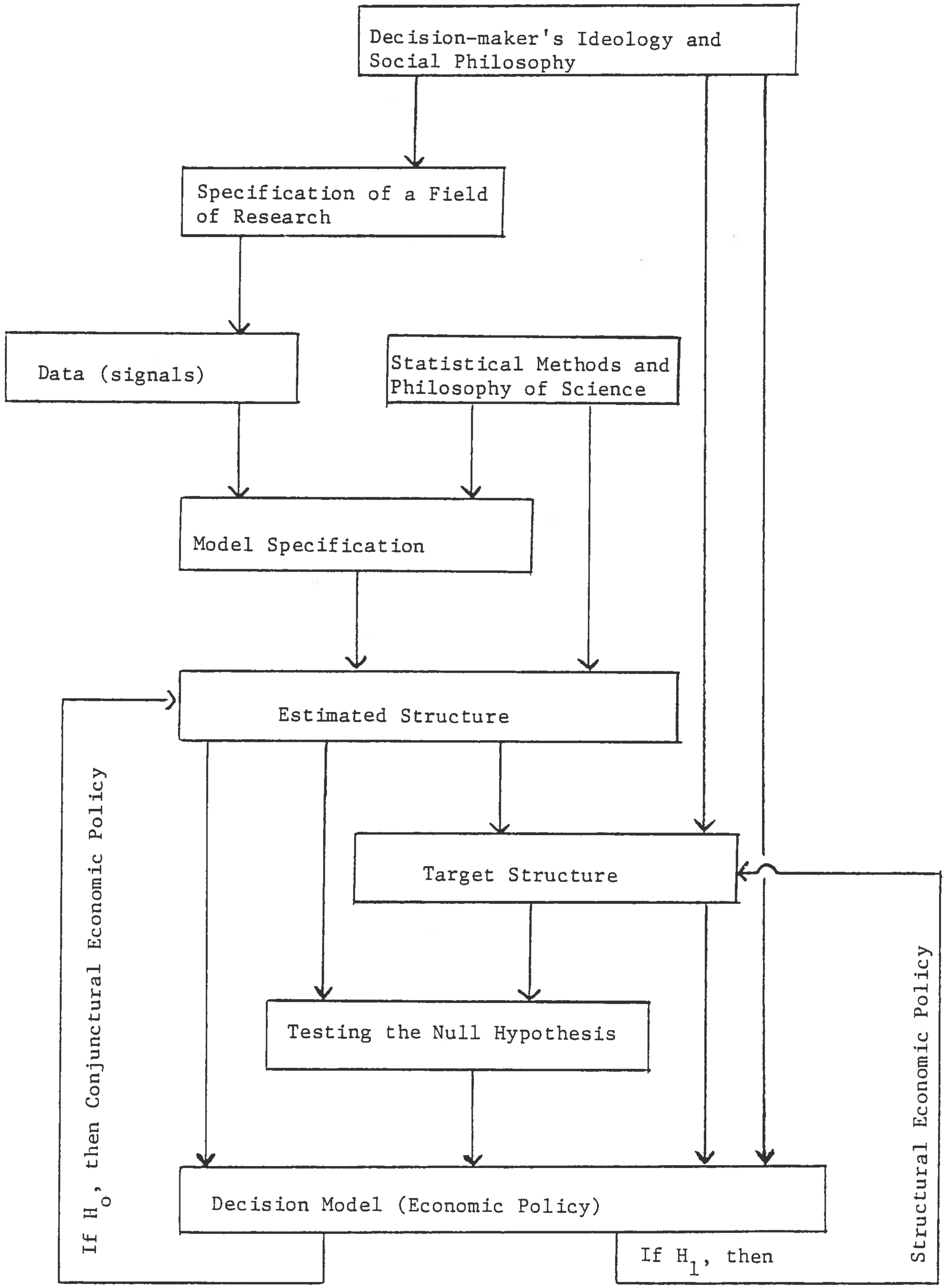
We now present a brief discussion of the meaning and content of each one of these steps in economic research. Fig. 3 illustrates their structure.

6.1. Specification of a field of Research

This first step asserts that aspect of reality which is the object of inquiry, and as such is a statement of existence. It commands an unequivocal definition of the committed field of inquiry. H. Poincare' stressed its essential role for the successful explanation or solution of a research project when he stated that a well defined problem is already fifty percent solved.

Ortega y Gasset (1946) stated it with both philosophical rigor and poetic beauty, when he wrote that (p. 144), "before a thing becomes an object of cognition it must have been a problem, and before it becomes a problem we must have found it strange." This statement emphasizes the role of observations and ideas, i.e. watching and wondering, to motivate the specification of a research project. It clearly embraces the theoretico-empirical

Fig. 3



Decision-maker's Ideology and Social Philosophy
Specification of a Field of Research
Data (signals)
Statistical Methods and Philosophy of Science
Model Specification
Estimated Structure
Target Structure
Testing the Null Hypothesis
Decision Model (Economic Policy)
If H o, then Conjunctural Economic Policy
If H 1, then
Structural Economic Policy

philosophy of science.

The specification of a field of research is either the aftermath of a preanalytic knowledge, which Schumpeter called vision, or the pursuit of the research so far accomplished. Schumpeter (1954, p. 41) stated that "in order to be able to posit to ourselves any problem at all, we should first have to visualize a distinct set of coherent phenomena as a worth-while object of our analytic efforts. In other words, analytic effort is of necessity preceded by a preanalytic cognitive act that supplies the raw material for the analytic effort. In this book, this preanalytic cognitive act will be called vision." Schumpeter vision is thus another form to rationalize the interface of observations and ideas as a powerful force leading to a scientific inquiry and scientific model building.

Schumpeter's vision takes the form of an intuitive and preliminary structure, where the empirical domain in Wold's models for knowledge plays a relevant role. This is apparent when Schumpeter stated (p. 561) that "in every scientific venture, the thing that comes first is Vision. That is to say, before embarking upon analytic work of any kind we must first single out the set of phenomena we wish to investigate, and acquire intuitively a preliminary notion of how they hang together or, in other words, of what appears from our standpoint to be their fundamental properties."

6.2. Model Specification of the Observed Structure

The specification of a field of inquiry demands a coherent explanation by means of a theoretic construction. It usually takes the form of a scientific model. Should we start from scratch, or see things in a different light not to be found in the facts, methods and results of the preexisting state of the science (which is the case that would lead to a paradigm change, or the formulation of a new scientifc research program), or follow up the research from the state left by our predecessors (which is the case, when we work within an established paradigm, i.e. the practicing of "normal" science, or within a given scientific research program, with the expectation of keeping it as a progressive research program), we have to interrogate "nature", i.e. to monitor the information it provides in relation to our specified field of inquiry. In this context, we can modify Heisenberg's (1958) statement(3), saying that although the object of the scientific research is Nature, and by this we mean, according to Table 1, matter, life or society, the outcome of it is Nature subject to the interrogation of men. In the particular case of the social sciences, it exhibits another form of uncertainty principle given by the observed fact that society answer to the interrogation of men is not invariant with respect to the amount of information and the theory applied to process it, i.e. Morgenstern's absorption theory.

By interrogating "nature" the researcher tries to infer or identify T. The signals transmitted by T take the form of prices, employment, output, etc. They belong to the empirical domain E, and jointly with the researcher's ideas constitute the starting point for the identification of the theoretic structure T, in a theoretico-empirical approach to scientific model building. It encompasses the following stages:

i) observation of reality, i.e. watching the functioning of T, or observing its signals;

ii) statement of the primitive ideas, the main analytic categories, and the level of disaggregation and aspiration for the model to be built;

iii) grouping of the observations according to the categories of analysis and planned level of disaggregation;

iv) <u>ex-ante</u> analysis of the signals by means of diagrams, ratios, index numbers, correlation, regression, etc.;

v) specification of a descriptive or explanatory model M_1 as the theoretic representation of T;

vi) estimation of the unknown parameters of M_1, which gives an <u>estimated</u> structure S_1 of the <u>unknown</u> economic structure T;

vii) <u>ex-post</u> analysis, i.e. the estimated structure S_1 is used to forecast new signals generated by the unknown economic structure T. If the forecast accepts the null hypothesis of a non significative difference between the observed (new signals) and the forecast values, we retain S_1 as an appropriate representation of T. If the null hypothesis is rejected, then we return to the first stage, starting again the ex-ante and ex-post process of analysis, in the quest of a relevant modelization of T;

viii) the final stage concerns the application of knowledge, i.e. the practical utility of a model and its estimated structure to be used for the purposes of description, explanation, prediction, and decision.

This process of model building corresponds to the matching or dialectical process between E and T in Wold's models for knowledge. Besides, the ex-post analysis brings to the fore the predictor specification approach to scientific model building introduced and developed by Wold (1959, 1963, 1984) and his school of statistics and econometrics.

In the process of model building, three sets enter as essential elements and at least one of them enters in an explicit form in the corresponding model specification. They are, the set of economic agents A, the set of technologies $\mathcal{T}$, and the set of institutions $\mathcal{J}$. They form the triplet $\{A, \mathcal{T}, \mathcal{J}\}$. Those sets that play an explicit role in the model specification form part of the matching process in Wold's models for knowledge; the others belong to the frame of reference, conditioning as a datum the model specification.

The level of disaggregation introduced in stage (ii) above determines the relevant markets and subsets object of inquiry. In its simplest form, a market for a given product is modelized by means of three statements, i.e. a supply function, a demand function, and a equilibrium condition. Should these statements exhaust the object of inquiry, then we are dealing, in the Marshallian tradition, with a partial equilibrium model. The equilibrium approach as a meaningful mode of theorizing an aspect of reality is being contested by the supporter of the disequilibrium approach steming from Keynes' (1936) general theory. Cournot (1838) anticipated this type of approach when discussing the equilibrating and disequilibrating forces operating in each market. For further elaboration and discussion on this issue, see Perroux (1975).

Under the assumption of a market for a given commodity and imposing the equilibrum condition, the only set that explicitly enters the model specification is the set of economic agents A, which is partitioned into two subsets, the producers (A_1) and the consumers (A_2).

The disequilibrium approach leads to a dynamic model specification. In the case of a single market, its simplest form requires a partition of A into three subsets, the producers (A_1), the consumers (A_2), and the intermediaries (A_3). Wold (1959) specified a market model in disequilibrium as a recursive model. This model was also discussed in Dagum (1968, 1969) in the context of structural stability.

In a single market, each subset of economic agents performs a role, and to each role is associated an endogenous variable. Hence, each role commands a statement purporting to explain it by accounting for the levels and variations of its associated endogenous variable, including the qualitative statements on the parameters and the partial derivatives.

In a multimarket model, each member of the partition set can play more than one role, such as the Keynesian model with three markets (product, money and labor), and two subsets of economic units (households and firms). The households play the consumer role in the product market, and the suppliers of labor in the labor market. The firms play the investor role in the product market, demanders for money in the money market and demanders for labor in the labor market. The technology of the economy is represented by a production function, and the institutional aspect of the money market by the supply of money. Thus, this simple multimarket Keynesian model is able to explicitly incorporate the triplet $\{A, \mathcal{E}, \mathcal{J}\}$, formed by the sets of economics units, technology and institution, and to retain multiroles for the partition members of A. This forms the core of the explanatory part of the Keynesian model to which is added the set of conventional statements (equilibrium conditions and identities) and the primitive ideas such as the principle of effective demand that encompasses all Keynesian models. Once the equilibrium conditions and the identities are worked out into the model, it is reduced to seven statements and seven endogenous variables. The latter are real (y) and money (Y) income, real (w) and money (W) wage rate, price level (P), interest rate (r) and employment (n). The qualitative statements on the partial derivatives ensure the independence and non contradiction of the set of statements; then the model is complete and coherent.

A model is the synthesis that results from the dominant application of the inductive method of inquiry. It represents a coherent whole which is considered as showing the truth more completely than as a mere collocation of parts, and for this reason, the whole possesses the superadditive property relative to the additive truthlikeness of its parts. The theoretical empiricism, as a philosophy of science, allows reason to perform the jump from the observations-ideas interaction to the scientific model building, cutting the Gordian knot of the infinite regress. Once a model is specified, it is subject to the analytical method of inquiry for the deduction of useful theorems or derived propositions. This is a natural follow-up of the search for system, i.e. the search for wholeness, that we called theoretic structure. The analytic method then takes place in its orthodox Cartesian interpretation, i.e. the splitting of reality into smaller units, and the recognition of individual causal relationships, that correspond to Descartes' second precept of his Discours de la Méthode.

6.2.1. System, Model and Structure

Since the thirties, the concept of model in economics, as it was introduced by R. Frisch (1935-36) and J. Tinbergen (1939, 1956), can be recognized as similar to the concept of system that in the fifties made its formal entrance in system science. Both concepts incorporate the essential dimensions of structure, function and evolution.

L. von Bertalanffy (1968, p. 38) defines a system as a "set of elements standing in interaction." For Mesarovic (1963, p. 7), "a general system is a relationship defined on a Cartesian product", which is formally equivalent to von Bertalanffy's definition. In mathematics, a space is defined as an ordered triplet $\{A, *, a\}$, where A is a set of elements, a is a member of A, and * is a set of operations in A obeying a set of axioms. Compared with Mesarovic's definition, this is more formal and specific. The modern system approach includes all the attributes entertained in the former definitions plus an explicit consideration of the functions or roles performed by its active units, as is apparent from von Bertalanffy's "elements in interaction."

According to Gini (1953), "a model is a simplified representation of the manner in which certain phenomena are related, or the manner in which they evolve." Here again we find the concepts of structure and function, to which Gini added the concept of evolution, placing it in a dynamic context.

A general definition of model or system is here proposed.

Definition of Model. A model is a set of interactive elements, functioning within a network of relations, and evolving in time according to the roles performed by its active units.

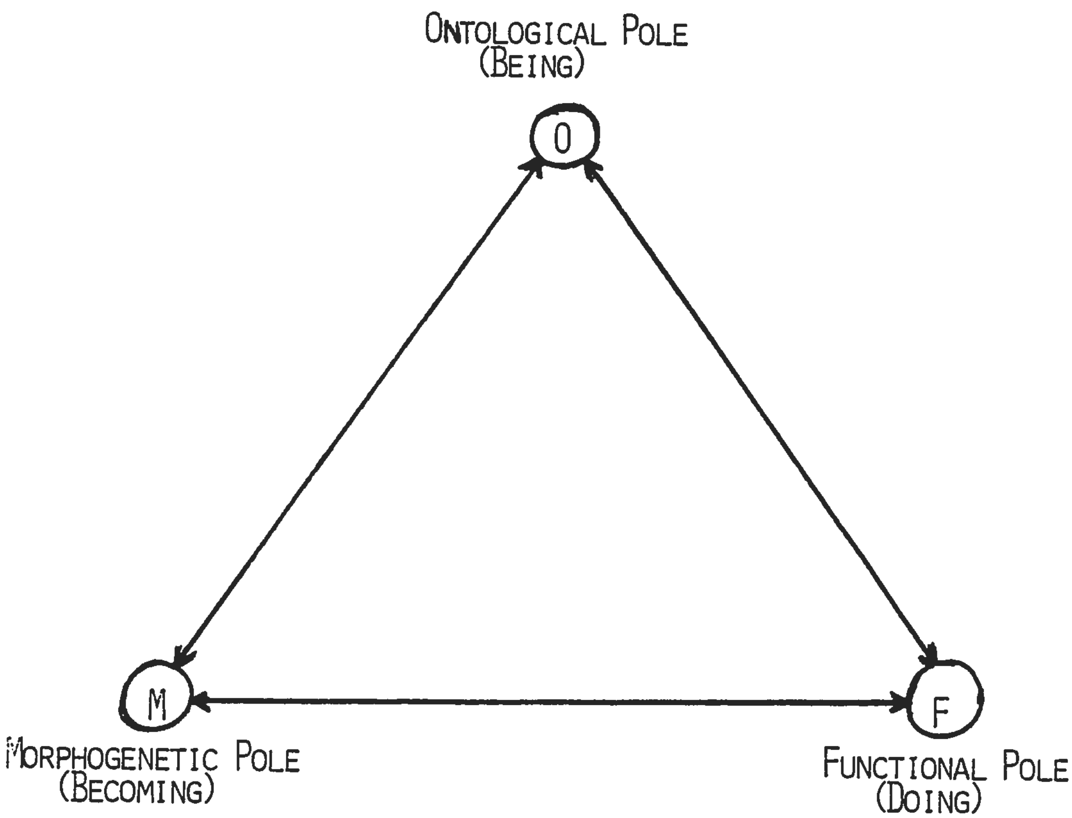
This definition includes the three main dimensions of a system (Le Moigne, 1977, p. 38). They are (Fig. 4), the functional (what an active unit does), the ontological (what is, i.e. the structure of relationships) and the morphogenetic (what an active unit becomes, i.e. its evolution). It follows from the functional-ontological-morphogenetic interaction, as is the case of observed economic systems, that what the active units do induces a dialetical process between being (the observed structure) and becoming (the evolving structure). The active units performance shapes a new structure, which corresponds to the praxis, and the new structure reacts upon the active units, modifying their function, which characterizes the inversion of the praxis. Another dialectical process underlying the system dynamics can also be outlined; it is between the couple structure-function and the environment. The function (praxis) of a class of subsets of economic agents transforms the environment, which in turn induces a change of the function, and with it, the structure (inversion of the praxis), and this process of interaction evolves over time.

Taking into account the specific characteristics and properties of economics as a science and the process of model building, a definition of model in economics is proposed.

Definition of Economic Model. An economic model is an idealized and simplified formal representation by means of a theoretico-empirical set of singular scientific statements concerning the observed characteristics of regularity and stability of a given field of research.

Fig. 4

THE DYNAMICS OF THE ACTIVE UNITS



The set of singular scientific statements deals with:

i) the modes of action and interaction among the members of a relevant partition of a set of economic units encompassed by their retained roles (often called behavioral relations);

ii) the modes of production (often called technological relations);

iii) the social relations of production (often called institutional relations).

They are articulated within the framework of:

iv) a set of existential statements that introduces the basic or primary assumptions and primitive ideas.

These statements can be complemented by the following types of conventional statements:

v) conditional statements (equilibrium relations); and

vi) universal statements (identities).

An economic model is always built from an implicit or explicit set of existential and conditional statements (types (iv) and (v) in our definition). They constitute the primitive and "unexplained" ideas and assumptions in the context of a field of inquiry, such as the principle of effective demand, supply oriented economy, law of supply and demand, surplus value, equilibrium or disequilibrium assumption, class of subsets of economic units, and perfect competitive markets. Their explanation can fall inside or outside the field of economics, or be interdisciplinary, but they are not the subject matter of inquiry within the specified field of research.

The statements of types (i), (ii) and (iii) constitute the set of singular scientific statements, because they account for the functions or roles performed by a relevant partition of a set of economic units, the modes of production, i.e. the spectrum of technologies at work in a given field of inquiry, and the social relations of production or institutional structures. As singular scientific statements they can be submitted to statistical tests of hypotheses, i.e. they are testable.

Finally, the type (vi) statements are always true by construction and are verified for all values of the specified variables. Therefrom, they belong to the class of universal statements. They relate real and nominal variables such as real (y) and nominal (Y) income and the price level P, or are associated with a given partition of the set of economic units, such as, the partition of the set A into households and firms, or into households firms and government, induces the identity Y=C+I, or Y=C+I+G, where the symbols stand for income (Y), consumption (C), investment (I) and government expenditures (G).

The historical and teleological properties of economics as a science determine the specification of unobservable variables such as planned, expected and random variables. Each unobservable variable commands a new statement. The most important methological approaches dealing with these types of unobservable variables are: partial adjustment, adaptive expectation, Muth's rational expectation and Wold's soft models (path models with latent variables).

Table 2 presents a classification of the statements contained in our definition of economic model.

TABLE 2

Classification of Statements

1)	Primitive ideas and primary assumptions (statements of type (iv) and (v)).	
2)	Singular scientific statements (types (i), (ii) and (iii))	2.1) Modes of action and interaction of a relevant class of subsets of economic units.
		2.2) Modes of production.
		2.3) Social relations of production.
3)	Universal statements (type (vi)).	

6.2.2. An Economic Interpretation of Lakatos' Methodology of Scientific Research Program

Lakatos' (1978) contributions emphasize the growth of scientific knowledge. The structure of his methodology for a scientific research program represents a step forward to Popper's and Kuhn's philosophies of science with respect to the assessment and validation of theories and models. To this end, Lakatos introduced important analytical categories such as the hard core, protective belt, positive heuristic, and progressive and regressive research programs. These analytical categories are put in correspondence with the class of statements introduced in our definition of economic model.

According to Lakatos, the hard core of a scientific research program comprises a basic set of assumptions which are protected from criticism and refutation. These assumptions are accepted by convention and considered irrefutable. This definition, however, is rather too dogmatic and of little potential applications to the social sciences, where ideology plays an outstanding role in the coexistence of conflicting research programs. Why should the hard core be protected from criticism and refutation? Why should it be considered irrefutable? By whom? We should instead interpret the hard core as constituting the corner stone of a school of thought, paradigm or scientific research program. In our definition of economic model, it corresponds to the primitive ideas and basic assumptions included under statements (iv) and (v), and to Wold's frame of reference in his models for knowledge.

In this sense, to the core (and considered by their practitioners as the prime moving force of a national economy) belongs: (a) for the neoclassical school, the supply side hypothesis steming from Say's law that supply creates its own demand, and the assumption of perfect competition in both the factor and the product markets; (b) for the Keynesian school, the principle of effective demand, the Keynesan three fundamental psychological factors and the labor market disequilibrium assumption; (c) for the Marxian school, the class struggle, the assumptions supporting the labor theory of value, and the appropriation of the surplus value; and (d) for the structural school of economics, the socio-economic infrastructure, which conditions the level of efficiency in the functioning of an economic system.

The acceptance of a hard core or set of primitive ideas and basic assumptions is of a paramount importance for the design of an economic policy. Should the principle of effective demand be used in a case study, such as the U.S. and Canada domestic demand for car and textile, where these domestic markets are competitioned from abroad (are not competitives), then an economic policy based on this principle will fail to realize what the theory predicts. Therefore, the criticism of the hard core of an economic research program or economic school is essential and prior to its application for decision purposes. That is, the acceptance of a hard core has unequivocal policy implications.

The criticism of a hard core takes the form of a conflict between school of thoughts. Precisely, the competing sets of primitive ideas or hard cores in Lakatos' terminology are the subject matter of discussion and controversy among schools of economic thought. Such is the case among the neoclassical, Keynesian, Marxian and structural schools.

The <u>protective belt</u> is defined as the set of auxiliary hypotheses that surround and protect the hard core, and are subject to confrontation with empirical observations. The protective belt in our definition of economic model is given by the set of singular scientific statements, i.e. those of types (i), (ii) and (iii); in Wold's models for knowledge, it corresponds to the outcome of the dialectical process between E and T.

Practitioners of a scientific research program submit themselves to its hard core content. They controversies take the form of a model specification dispute within a given school of thought, resulting in a sequence of models M_1, M_2,..., with different sets of auxiliary hypotheses and suported by the same primitive ideas. Such is the case of the sequence of Keynesian models and, more specifically, the sequence of Keynesian consumption function specifications (absolute, relative, permanent and life cycle hypotheses).

According to Lakatos, the positive heuristic guides the scientist in the construction of a protective belt, which results in a series of theories T_1, T_2, T_3,..., where "each subsequent theory results from adding auxiliary clauses to, or from the semantical reinterpretation of, the previous theory in order to accommodate some anomaly, where each theory in the series has as much empirical content as the unrefuted content of its predecessor" (Suppe, 1977, p. 662). It is "a powerful problem-solving machinery, which, with the help of sophisticated mathematical techniques, digests anomalies and even turn them into positive evidence." (Lakatos, 1978, p. 4).

In economics, the main body of positive heuristic is given by the content of econometric methods.

A research program is progressive if it is both theoretically and empirically progressive, otherwise it is degenerating. It is theoretically progressive if each new theory in the sequence, T_1, T_2, T_3,..., has some empirical content over its prodecessor, i.e. if it predicts some new facts. It is empirically progressive if some of the predicted new facts has been confirmed.

Lakatos (1978, p. 112) stated that "a reearch program is said to be progressing as long as its theoretical growth anticipates its empirical growth, that is, as long as it keeps predicting novel facts with some success (progressive problemshift); it is stagnating if its theoretical growth lags behind its empirical growth, that is, as long as it gives only post hoc explanations either of chance discoveries or of facts anticipated by, and discovered in, a rival program (degenerating problemshift)."

Observing the failures of the neoclassical monetarist and the Keynesian research programs to cope with the problems of inflation, unemployment, government deficit and interest rate we have to conclude that they are in a process of degeneration. The most we can say is that they are stagnating for they practitioners are running behind the empirical growth, adding auxiliary hypotheses, most of the times ad hoc hypotheses, to its predecessor in a effort to show some form of theoretical growth, and in this manner, trying to salvage the research program from degenerating.

6.2.3. Properties of Economic Models and the Approaches to Scientific Model Building

Since economics is a factual science, the inductive and dialectical methods of inquiry come to the fore during the process of economic model building (searching for systems). This process ends with the specification of an economic model by means of a set of singular scientific and conventional statements, which constitutes the axiomatic system within the framework of a hard core, i.e. a set of primitive ideas and basic assumptions. Thus, the model is the outcome of the process of observation-ideas-reason. Once the model is specified and accepted, the analytic and deductive method is applied aiming at deducing the corresponding set of theorems or derived propositions. Axiomatic system and theorems form the theoretico-empirical, axiomatico-deductive system or model belonging to an economic research program. Table 3 presents some of its properties.

TABLE 3

Properties of Economic Models

1)	Logical	Axiomatic system	Consistency
			Independence
			Completeness
		Theorems: Logically true	
2)	Empirical	Generality (theoretically progressive)	
		Validity (empirically progressive)	
3)	Operative		

An axiomatic system is consistent if it does not allow for any contradiction; no axiom in the system should contradict any other axiom. It is independent if no axiom can be proved as a theorem by assuming the remaining axioms. It is complete, if it is consistent, independent and contains one statement for each specified endogenous and unobservable variables.

The theorems or derived propositions have to be logically true, i.e. they have to be straight forward consequences of the analytico-deductive method applied to the axiomatic system.

A theoretico-empirical axiomatico-deductive system satisfies the property of generality if it is a germane, coherent and relevant representation of the aspect of reality object of inquiry. It should be able to encompass and to account for all the relevant observed facts pertaining to that object of inquiry and to predict some new facts compared with its predecessors. The latter corresponds to a theoretically progressive research program. The system possesses the property of validity if its theorems are in close correspondence with the empirical domain of a given field of research, and some of the predicted new facts have been confirmed. The latter corresponds to an empirically progressive research program.

Finally, a model or system is operative if it is viable in terms of available techniques such as quantitative methods in econometrics, computer capability and efficient technology.

A theoretico-empirical axiomatico-deductive system possessing the logical, empirical and operative properties is said to possess the attributes of rigor, relevance and realism. Rigor is an attribute associated with the logical properties and resulting from the applied scientific methodology, starting with the research design up to the model specification and its derived propositions, without ignoring the validation process of a model. Relevance is an attribute associated with the empirical properties and related to that aspect of reality object of inquiry, the expectation of the scientific community, predictions and the policy implications of the model. By realism, it is meant ontological epistemological and methodological realism.

For the factual science, the fulfillment of the logical properties is a necessary but not sufficient condition for a model to be a scientific part of knowledge; ergo for the empirical properties. Both logical and empirical properties are necessary and sufficient conditions. Fig. 5 illustrates this statement, where L and E stand for logical and empirical property, respectively; the symbol $\wedge$ stands for the conjunction of two statements, and $\sim$ for the negation of a statement.

$E \wedge \sim L$	$\sim E \wedge L$	$E \wedge L$

Fig. 5: Models possessing logical (L) and/or empirical (E) properties.

The three cases illustrated in Fig. 5 are related to the three approaches of philosophy of science to the construction of scientific model. $E \wedge \sim L$ symbolizes the empiricism; $\sim E \wedge L$ the idealism, and $E \wedge L$ the theoretical empiricism. To $\sim E \wedge L$ applies Kierkegaard's assessment of Hegel's system quoted above, and also Bertrand Russell's (1919, p. 71) observation that "the method of postulating what we want has many advantages; they are the same as the advantages of theft over honest toil."

6.3. Estimation of the Theoretic Structure

Once the theoretic model of the observed structure is postulated as the explanatory model of a given field of inquiry, the next step requires its parameter estimation. For this we make use of the appropriate method. Wold discussed this issue in several seminal contributions. He made a comparative study of the properties of the maximum likelihood and the least squares methods of parameter estimation. Following Wold (1981, 1984.b), the former is parameter-oriented and the latter is prediction-oriented. In his analysis, Wold distinguished two categories of models, path models with manifest (directly observed) variables, and path models with latent (indirectly observed) variables. Wold (1984.b) observed that "prediction specification is of broad scope in three dimensions: date input, theoretical model, and operative purpose".

In econometrics, a model is defined as a family of structures. Hence, it can be parameterized, i.e. defined by means of a parameter space $\Theta = \{ \theta \mid \cdot \}$, associated to the mathematical law of correspondence among the variables included in the model specification. Each $\theta \in \Theta$ define a structure which is obtained by either a parameter-oriented or a predictor-oriented mehtod of estimation. For a documented study of the properties, advantages and limitations of alternative predictor specifications, see Wold (1984.b) and the references in that paper.

6.4. Specification of a Target Structure

The model specification and its estimated structure correspond to the second and third steps respectively, of our methodology of economic research program. They belong to the realm of positive economics, i.e. the ontological dimension of economics, more precisely an ontological realism, and purport to answer the question "what is."

Economics, as all factual sciences, is a science for action. Accordingly, the Spanish philosopher Juan Luis Vives (1492-1540) observed that knowledge is of value only when it is put to use, and Marschak (1953, p. 1) stated that "knowledge is useful if it help to make the best decisions."

As a factual science, economics embodies the knowledge of an aspect of reality, which takes the form of an economic structure. As a science for action, the knowledge it embodies helps the decisionmaker's specification of a target structure to be realized within a finite time horizon. Its specification belongs to the realm of normative economics and purports to answer the question "what should be."

The decisionmaker's specification of a target structure is a contituent part of his representation of the future of a society's national structures. In particular, the specification of a macro-economic target structure must be an atainable representation of the future in function of the observed structure, and the decisionmaker's ideology and social philosophy.

6.5. Testing the Null Hypothesis

It follows from the last two (third and fourth) steps of the proposed methodology of economic research that we are confronted with two structures, the observed (S) and the decisionmaker's target (D) structures. Before the decisionmaker commits himself to carry out a given course of action, he must decide first if there is or there is not a significant difference between the observed and the target structures. For this we apply the statistical methods of hypothesis testing, where H_0: S=D is the null hypothesis, which means that there is no significant difference between S and D; hence S and D can be considered as two equivalent representations of the same theoretic structure T. The alternative is the composite hypothesis H_1: S=D, which means that D represents a target structure significantly different than the observed structure represented by S.

For a test of hypothesis based on a distance function between structures, we refer the reader to Dagum (1983).

6.6. Specification of a Decision Model

A decision model is a consistent set of statements specifying a course of action or strategy to achieve a given goal or target. Two essential concepts emerge from this definition: the course of action and the target. It is apparent that an explanatory model, with its associated set of endogenous, exogenous and lagged variables has a cause-effect base. Having the purpose of achieving a given target, a decision model should act on the causes to produce a desired effect. Hence it must act on the exogenous variables that are controllable by the decisionmaker. The selection of the controllable variables as steering variables defines the instrumental variables, and their corresponding tuning determines the course of action. The chosen targets correspond to the planned time path of the selected endogenous (effect) variables, called target variables.

The choice of the target variables and the intensity of their relative use in macroeconomic decision models clearly reveal the decisionmaker's ideology and social philosophy.

A decision model can pursue either a more efficient performance of the same structure, or a structural change. The former applies when we accept the null hypothesis of no significant difference between the estimated and the target structures; the latter applies when the null hypothesis is rejected. These two possible courses of action define, respectively,

i) a conjunctural (business cycle) economic policy; and

ii) a structural economic policy.

The former performs within the theoretic structure to accomplish its goals, whereas the latter aims at the change of a given structure as the more efficient, or only course of action to accomplish the purported effect for the target variables.

In the developed industrialized countries, mainly Great Britain and the U.S., the failure to understand the circumstance(2) conditioning each type of economic policy is at the very base of the increasing frequency and intensity of recessions, the coexistence of inflation and unemployment, and the clear signs of the mainstream economic research program becoming a degenerating, or at least a stagnating, research program. Assuming a theoretical growth, it lags behind the *fait accompli* (empirical growth), and most of the times the claimed theoretical growth is the result of an ingenious collection of *ad hoc* assumptions, or in Russell's incisive words, the result of postulating what they want.

7. THEORETICAL EMPIRICISM IN THE FACTUAL AND METHODOLOGICAL SCIENCES. SOME CLASSIC EXAMPLES FROM THE HISTORY OF SCIENCE

The factual property underlying the construction of scientific models goes beyond the substantive science and is also observed in important fields of mathematics and statistics. Moreover, mathematics appears to have been the first scientific domain to formalize a highly sophisticated and consistent model as a theoretical counterpart to the empirical domain. It was done by Euclid, about 23 centuries ago, and could be presented as an archetype of theoretical empiricism.

In a lively contribution, von Neumann (1947) discussed the empirical background of mathematics. He stated (p. 182) that "it is undeniable that some of the best inspirations in mathematics

-in those parts of it which are as pure mathematics as one can imagine- have come from the natural sciences(...). Geometry was the major part of ancient mathematics(...). There can be no doubt that its origin in antiquity was empirical and that it began as a discipline not unlike theoretical physics today. Apart from all other evidence, the very name 'geometry' indicates this. Euclid's postulational treatment represents a great step away from empiricism, but it is not at all simple to defend the position that this was the decisive and final step, producing an absolute separation." Von Neumann's observation about Euclid's postulational treatment representing a great step away from empiricism is consistent with the theoretical epiricism philosophy of science, whereby reason introduces a point of discontinuity in the process of observations, ideas and reason. Hence, it is a great step away from empiricism, leading to the abstract specification of a theoretical model and keeping at the same time the observation-ideas interaction as a supporting base for the model specification and validation.

Another classic example of scientific model building in the context of theoretical empiricism can also be drawn from mathematics. It is calculus, or rather all analysis steming from it, which constitutes the first accomplishment of modern mathematics. There are undeniable evidence supporting the empirical origin of calculus, which evolved to become real analysis, which, by its degree of abstraction, became a great step away from empiricism. Archimedes' and Kepler's attempts at integration of surfaces and volumes with curved surfaces, respectively, are cases in point. The main discoveries in the field by Newton and Leibnitz recognize an explicit physical motivation to serve as a mathematical method for the development of classical mechanics.

In astronomy, an outstanding example of scientific empiricism was given by the works of Tycho de Brahe, Kepler and Galileo. After realizing that astronomical tables based on the Ptolemaic model were much too inaccurate, Tycho compiled astronomical observations that led him to abandon the Ptolemaic model but without accepting the Copernican one. These observations, carried over for more than twenty years and accomplished in pretelescope times, were left with Kepler in Prague, where he moved and met Kepler in 1599. On the basis of Tycho's observations, Kepler formulated his theories. His main contributions are addressed to explaining the form or structure of the phenomena. The dynamic approach, i.e. how the phenomena evolve in time is Galileo's concern. Thus, the triplet, Tycho, the observer, Kepler and Galileo, the theorists, are at the very base of the theoretico-empirical development of modern natural science.

In the social sciences and humanities, the role of observations to supporting the scientific model building was taking place later in time and showing a lesser spectacular achievement than in the natural sciences. Von Neumann and Morgenstern (1944, p. 4) observed that "the empirical background of economic science is definitely inadequate. Our knowledge of the relevant facts of economics is incomparably smaller than that commanded in physics at the time when the mathematization of that subject was achieved." A fortiori, we could say it for all social sciences. Morgenstern (1950) rigorously developed this subject matter in his classical research on the accuracy of economic observations. Nevertheless, the social sciences also exhibit some important examples of theoretical empiricism such as that of the triplet Pierre Bayle, Voltaire and Montesquieu. Bayle is regarded as a founder of 18th century rationalism. His masterpiece Dictionnaire historique et critique, first published in 1697, was an extraordinary source of historical information and criticism. Bayle's observations and criticism of historical life allowed Voltaire to write his celebrated Essai sur les moeurs et l'esprit des nations, a masterpiece of historical analysis of customs and spirit of peoples. His work does not consider the outstanding features such as political conspiracies, revolutions, wars and battles, without intertwining them with the custom and spirit of societies. Montesquieu complemented Voltaire contributions to both the structural and the dynamic approaches. For him, the ultimate reality and prime mover in the growth of nations is not made of fixed patterns but of acting impulse, and above all, the decisionmakers' acting impulses.

The French physician F. Quesnay appears to have been the first scholar to set down in some detail the rudiments of an economic model. His contributions were not the outcome of the theoretico-empirical approach to model building, but rather an analogic mode of inquiry, whereby his famous Tableau économique evolved from a biological analogy, i.e. the blood circulation in human beings. Almost half a century later, Adam Smith provided a coherent analysis of the nature and causes of the wealth of nations, without offering a formal model as we understand it today. His contributions recognized an empirical background, that of England's rising industrial and financial capitalism at the time of the first industrial revolution, and embodied a clear policy implication, the economic liberalism.

Among other contributions, Ricardo avanced a theory of income distribution based on the marginal and the surplus value principles. These methodological principles and his scientifc contributions provided the bases to the development of both the neoclassical and the Marxian schools of economics. The former exclusively adopted the marginal, and the latter the surplus value principle.

The observed population and food growth rates supported Malthus specification of the geometric and arithmetic series for the time path of population and food outputs, respectively, and to the Malthusian model of population growth.

Cournot modelized the monopolistic market and advanced the first systematic thought on the theory of general economic equilibrium, which later on became Walras most celebrated achievement. Mainstream economics started to depart from the theoretico-empirical mode of scientific model building with Walras and became dominated by an aprioristic, i.e. idealist philosophy of science.

8. CONCLUSION

As a philosophy of science approach to the construction of scientific models in the factual science, the theoretical empiricism is considered to be the highroad leading to the explanation of an aspect of reality, be it based on either matter, life or society. The implied scientific model is said to be rigorous, relevant and realist. Compared to former model specifications of the same aspect of reality, it has a greater generality and validity and thus, it belongs to a theoretically and empirically progressive research program. It has explanatory power, and under the assumption of some form of structural stability, it has the capability to predict expected and new events, whereby some of the new events predicted are afterward confirmed. This approach is associated with the contributions of Aristotle and Saint Thomas Aquinas, and the resulting specified model is the outcome of an intertwined (feedback) process of observations, ideas, reason and scientific model building.

Two particular and extreme versions of theoretical empiricism are the empiricist (Democritus, Bacon, Locke and Condillac) and the idealist (Plato, Descartes, Kant, and Hegel) philosophies of science. The former gives much too attention to observations and neglects the creative roles of ideas and reason, whereas the latter neglects the role of observations, overemphasizes the roles of ideas and reason, resulting in a priori constructions of science detached from reality. In synthesis, theoretical empiricism share with empiricism the determination to learn primarily from experience, and with idealism the importance attached to ideas and reason. Wold's models for knowledge are a cogent synthetic representation of theoretical empiricism as a general rationale to scientific model building.

A program for a methodology of economic research is proposed and discussed within the framework of theoretical empiricism. Economics as a science for action brings to the fore the policy implication of scientific model building, and the historical and teleological properties condition the general rationale to scientific model building. These properties motivate the active participation of the path (memory variables) and the decisionmaker's representation of the future (project variables and expectations) in the process of model building. The economic units, like the god Janus, look both backward and forward before

making decisions. The first three steps in the proposed research program in economics are in correspondence with Wold's models for knowledge; of the remaining three steps, the null hypothesis is of methodological character, and the specifications of a target structure and of a decision model belong to the realm of normative economics.

Some classical examples drawn from the history of science substantiate the role of theoretical empiricism as a general rationale to scientific model building in both factual and methodological sciences.

NOTES

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(1) Should the stretching of the theory fail to fit unexplained phenomena, then the last three steps in Kuhn's approach would follow. If this is the case, we move from the dialectical process between E and T leading to a sequence of model specifications within the same paradigm or research program, to a proces of paradigm change.

(2) To the term "circumstance" is attached the rich philosophical meaning that summarizes J. Ortega y Gasset's philosophical thought. Ortega y Gasset (T. VI, p. 347) wrote, "I am myself and my circumstance. My work is, in essence and presence, circumstancial. By this I mean that it is deliberate, because without deliberation, and moreover in spite of opposing purposes, it is clear that man never has done anything in the world that was not circumstancial."

(3) Heisenberg (1958, p. 24) stated that "the object of research is not longer nature itself, but man's interrogation of nature."

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