Braiding

The

Triadic Codex & Triple Helix

The
Sociophysics
of
Nature-Culture-Nurture
&
Academy-Industry-Polity

By

Paris Arnopoulos

Of

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INTRODUCTION

The modern construction of formal social system models in various disciplines has been going on for at least a generation now. These models try to describe, inscribe and prescribe certain aspects of social behavior aiming to improve our knowledge or control of interhuman relations. The complexity of social systems however has always limited these models either in depth or breadth. This trade-off between qualitative and quantitative aspects is perhaps in the nature of things, so it still remains to find a golden mean which optimizes both.

One way to do this is by a judicious use of mathematics that adds rigor to concepts and packs more information with greater exactitude than plain words. A good beginning was made thirty years ago by the global models of the Club of Rome, but for many reasons, not much progress has been made since. Now with the increasing knowledge of chaotic systems and improving sophistication of computers, we should renew our efforts in this direction.

This study makes such attempt by recapitulating the fundamental requirements of formal social models, by relying on the general Systems Unification Model of the recent Theory of Sociophysics, whose Triadic Interactive Paradigm juxtaposes nature-culture-nurture as the three aspects of reality. Consequently, natural laws and social norms are metaphoric and isomorphic, thereby optimizing symbiotic and synergistic relationships between them.

On that basis, the proposed model focuses on the three central sectors (political-economic-cultural) and relations (matter-energy-information) of the social world, keeping in mind that all these exist and ultimately depend on the underlying natural-physical environment of planet Earth.

In order to make such huge task more manageable in this specific instance, this short paper interfaces with the triple helix paradigm by weaving its triadic social focus-locus with the power-wealth-data flows among its state-market-school centers. In this way we can concentrate on the most significant influence-finance-science transactions of the polity-industry-academy triangle.

This scheme should give a clear idea of the most important elements and activities that must be taken into account in any more sophisticated models of the social system which could follow. To this end, we proceed by introducing the basic concepts of social theory and then apply them to a triadic social model.

The first half of this paper presents an executive summary of the Theory of Sociophysics, sufficient for our purposes here. The second half will then translate this general theory into a mathematical model especially suitable as a triple helix. What follows is thus only a primary contribution to the long ongoing search for the elusive optimal dynamic model of society.

1. THEORY

The Theory of Sociophysics postulates reality as a construct of three triadic facets: SET (space-existence-time); MED (matter-energy-data); PEC (polity-economy-community). This chapter provides a summary description of each of these aspects as the context, concept and content of our universe of discourse.

1.1. SET CONTEXT

According to the SET context of Sociophysics; whatever else they may be, human societies are first and foremost physical systems existing within a space-time framework. This basic conceptualization allows the best way of exposing and explaining social structures and functions. Let us very briefly look at each of these three primordial dimensions.

1.1.1. Mass.

Following General Systems Theory, societies are considered to be systems of a particular type. As fuzzy sets of interrelated components, real systems are substantial entities existing in a spatio-temporal framework. Unlike conceptual systems, such as models, dreams or utopias, real or physical human societies are composed of people plus their creations and possessions, all of which interrelate and interact within a spatial location of the Earth's geography and temporal duration of the world's history.

This definition of society implies a physical system of a certain material substance whose mass is a function or sum of its population, creation and possession:

$$m = f(h, c, p) = b' h + b'' c + b''' p$$

where m = sociomass; b = social parameters; h = human biomass (~300 billion Kilos); c = artificial creations (products, buildings); p = domesticated possessions (plants, animals).

That equation indicates that societies differ significantly as to their demographic sociomass. Thereby, the contemporary 200 nation-states range from the mini to the maxi in their membership. Added to people, the quantities of material possessions and creations differ substantially from one society to another. Agricultural societies have very few commodities, whereas industrial societies have many capital goods.

More important than mere quantities however, are the ratios h/m and c/p that determine the social qualities of life. Obviously, poor societies have smaller ratios than wealthy ones because the latter accumulate a higher amount of artifacts per capita of their population.

1.1.2. Area

When space is combined with mass, we get the geographic aspects of society, since it exists somewhere and occupies a certain territory on the surface of our planet. Given in longitude and latitude, much as Cartesian coordinates (x, y, z), location relates societies to each other in a topological configuration whose relative strategic position on the world's map is of critical importance as attested by geopolitics.

The area occupied or inhabited by different societies varies widely from very small to continental proportions, something that gives them certain advantages and disadvantages. An important factor relating people to their living space is density (d = m/s), as the number of people per unit area. This index differentiates hunter-gatherer societies averaging a person per ten square miles from rural (100 persons) and urban (10,000) systems. Obviously city congestion which packs large masses in small spaces has great social repercussions because it makes a difference in how people live.

1.1.3. Change.

The third aspect of our model adds time to space and mass, thus completing the SET paradigm. All three aspects are directly proportional, because as one varies, so do the others. However, unlike tridimensional mass or space, time is unidimensional; its arrow always moves from past to future, via the

present, never retracing its steps. This limitation makes social time or history very different from social space or geography.

Social systems exist in space and time, so they are indexed by them as: S = f (set). As dynamic systems, societies are in constant flux, undergoing a change in their components (x1, x2, x3,...) over time. The history of component x then is a function of its previous states: x = f (xt, xt-1, xt-2,...xt-n). For any discrete time period, a change in x is the difference between its state in two time periods: dx = (xt-xt-1)dt, or xt-xt-1=dx/ dt.

A displacement in space combined with the passage of time gives us motion or velocity (v =ds/dt). Other than nomadic types, most societies have become sedentary, occupying a fixed location over long periods of time. Sociomotion therefore involves only the internal activity of sociomass within a given space.

The velocity of this motion differentiates active or dynamic from passive or static systems. Traditional societies are distinguished by their slow motion, where social activities happen leisurely, whereas life is much more frantic in modern societies. Not only that, but things move faster as time goes by, thus accelerating (a = dv/dt) by leaps and bounds, something that disorients people with future shock.

Finally, when we combine mass and time, we arrive at the notion of social inertia (r = dm/dt). This means that the rate of variation in sociomass over time indicates the velocity of social change. Developing societies increase their sociomass much faster than stagnating societies. Other things being equal, large mature societies have greater inertia because of their accumulated mass, so they tend to slow down. Once they get going however, massive systems acquire great momentum (q = mv) which is as difficult to stop when moving, as it is to start when at rest.

1.2. MED CONCEPT

From what has been said so far, it does not mean that society is merely a physical system. Obviously, it is much more than that, so we shall now introduce its other aspects with the new MED (matter-energy-data) triad. This triadic concept shows both sides of the material coin, as well as its immaterial form. Our social reality then consists of matter, energy and symbols in various combinations or permutations, S = f (med), as we explain next.

1.2.1. Field.

Sociophysics accepts the precepts of the Social Field Theory by recognizing the existence of charged fields (f = c/s) around all matter. Material bodies create gravitational and electromagnetic fields that affect their relations with each other. Well-connected social systems with strong institutions have such fields whose strength is directly proportional to the number and ties of their constituents and inversely proportional to the distance between them. Massive or dense societies create strong fields that give them a great sphere of influence.

Of course, influence makes the world go round because it effects change through the application of force fields. In order to change anything, force must be applied. Force is therefore defined as whatever is required to change the state of a mass: F = dq/dt = mv/t = ma. Social force is thereby the means of social change, the more massive a society or the more radical its change, the greater force is needed to do the job.

In doing any job, force performs work: W = Fs = mas = mv^2. This means that some work must be done in order to bring about social change. If that change is needed fast then one must exert a lot of power: P = W/t =mav = Fv. By this mathematical transformation, we have arrived at this crucial notion of power politics as well as physics.

Social power however, unlike physical power, does not move inanimate objects but human masses to act far and fast. As we will see later on, powerful people can do that by influencing social behavior by the communication of information, rather than the transportation of matter or energy.

1.2.2. Energy

As Einstein eloquently discovered, matter and energy are equivalent and interconvertible. Defined as a function of mass and motion, energy is either potential (m, s) or kinetic (q, v), depending on where a

body is located or how fast it travels. In that sense social energy is proportional to its stocks in place or masses in motion.

The importance of energy is evident by the fact that it provides work. For that reason, E and W are equivalent under certain conditions: $E = mc_2 = mas = Fs = W$. This equation allows high stocks of potential energy to be converted to kinetic energy by performing social as well as physical work.

Since any transformation of energy produces heat, work, as any kind of action ($A = Et$), raises the temperature of its environment. So, centers of activity are also hot spots with high temperatures. As such, they are also associated with high pressures: $p = f(n, m, v) = F/s$. Social pressure therefore increases with demographic density and collective activity, thus raising the ambient heat and temperature.

Energetic or dynamic societies may be either productive or destructive, depending on whether they direct their efforts in building or demolishing systems, something that brings us to the next topic of discussion.

1.2.3. Data

In order to constitute a system, matter and energy must be organized into a certain configuration. The very notion of system implies some order by which its constituents are arranged. In this way, matter is shaped and energy is channeled in a particular pattern.

Natural evolution is a process of increasing order and decreasing chaos. This direction from simplicity to complexity culminates in organic bodies and intelligent minds that derive meaning from symbols. In a similar vein, social development complements natural evolution by helping humanity realize its potential.

The central means toward that goal is the creation and communication of information. In that sense, information [$I = \log (o/i)$] puts matter and energy in form by gaining data as well as organizing and promulgating it as collective knowledge. This process also increases the efficiency of work and the effectiveness of action, thereby slowing down the inexorable march of natural entropy.

Informative societies are negentropic because they increase systemic organization and decrease environmental degradation. Accumulating human knowledge also improves social control ($C = a/t$), since it regulates social change in a more enlightened manner. For that reason the exercise of responsible social power requires strict political control ($P = msC$), as we see next.

1.3. PEC CONTENT

Persisting relations form structures, while continuous actions form processes. Since humans are both logical and biological organisms, they have needs, wants and goals, thus making their social structures and processes functional or purposive. Social systems are thus artifacts that serve to fulfill the necessities of human life, the desires of its imagination and the objectives of public policy.

Like organisms, societies develop specialized tools to perform particular tasks to attain these ends. We herein denote the PEC (polity-economy-community) triad which contains the necessary and sufficient structures and their corresponding functions to handle all social needs. It is within this PEC triad that we find the particular GIA (governmental, industrial, academic) institutions, as summarized below.

1.3.1. Economy

This is the primordial sector of the social system and provides its infrastructure upon which everything else is based. The central function of the economy is divided in a primary (exploitation of raw materials and energy resources from nature), secondary (transformation of these inputs into valuable commodities) and tertiary (exchange of these goods or services in the market place).

These extractive, productive and distributive functions, carried out by economic institutions (farms, mines, factories, laboratories, banks, shops), serve as metabolic structures and processes whereby social, like organic, systems are able to maintain themselves in a living and growing mode. Economic development is the process of increasing efficiency and productivity in performing these tasks.

1.3.2. Community

Based on the production of the economic infrastructure, the social structure engages in the consumption of the provided goods and services in order to create a certain quantity and quality of social life. The resulting culture includes traditional LARK (language, art, religion, kinship) functions carried out by social institutions (schools, studios, churches, families) that educate, inform, communicate, recreate and enculturate people to a particular way of life. Of course, cultural creations also influence economic productions, thus effecting a direct interdependency loop between these two sectors.

As the economy provides the metabolic, so community infuses the genetic and mnemonic function of society by the procreation of natural genes and propagation of cultural memes. Compared to natural evolution, cultural education is quite rapid and partial, creating many time lags and space gaps among people. Thus the many problems of adaptation between generations, separation between classes or comprehension between nations, due to their differing interests, opinions and values inevitably produce social frictions and conflicts.

1.3.3. Polity

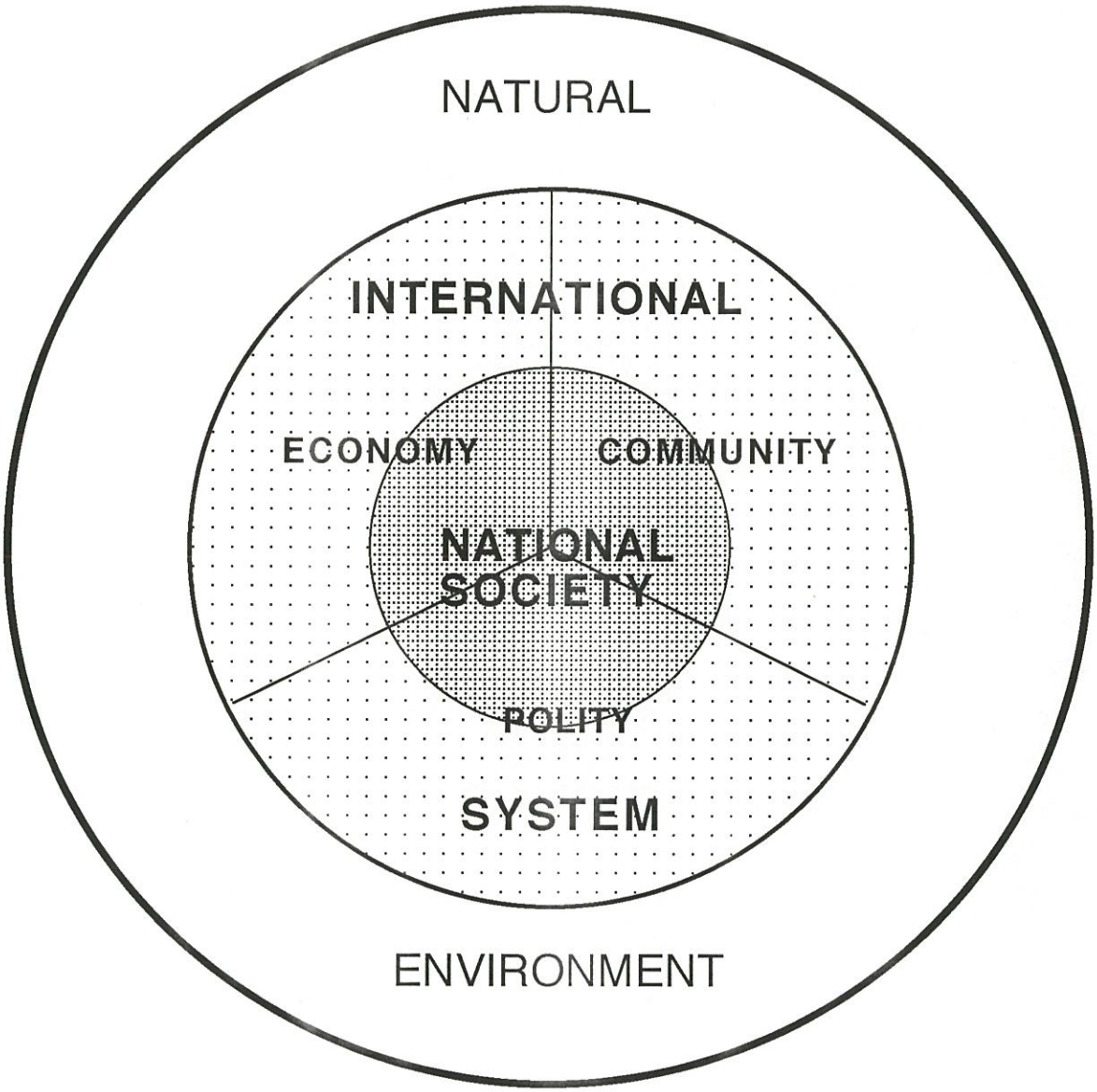
Finally the political superstructure provides a way of resolving socio-economic conflicts by its cybernetic function. The polity is supposed to govern society by operating as a homeostatic and teleonomic mechanism which legislates norms and regulates acts through its political institutions (parliament, ministry, court, army, police, party), thus maintaining external security and internal harmony.

Political power influences social behavior by promising awards and threatening sanctions, thus shaping public opinion and developing a collective mind. In order to meet demands of protection, organization and redistribution made upon it, government is provided with economic and social support in the form of tax and draft, thus converting popular loyalty into public policy.

As a synoptic picture of our conceptual framework, we present below a three concentric circle SIN diagram that illustrates the realms of an egosphere, sociosphere and ecosphere. The natural environment (N) of planet earth encloses the cultural supersystem of global world which is divided into the international system (I) containing couple of hundred national systems (S). Intersecting these social systems are their PEC sectors. Finally at the very core of this anthropocentric schema is the generic individual. This simplified perspective should give a good idea of our model, whose details we elaborate throughout the text.

(SIN Circle Diagram)

SIN
NATIONAL-NATURAL
REALMS



WORLD PEC & EARTH MED

2. MODEL

Now that we have given a general outline of Sociophysics, let us try to convert its most significant elements into a mathematical model pertaining to the particular attributes of the triple helix. This formality will represent the three central aspects of social reality that interest us, by representing and manipulating them symbolically. To do so, we set out the structures, functions and processes of our model, as descriptive elements of the social system. The following sections treat each of these aspects.

2.1. STRUCTURE

Every system must have a structure, formed by its components and their connections. We hereby outline these elements and their attributes, as well as the rules by which they are related, thus exposing the state vectors, ideal values and structural codes of our model.

2.1.1. Vectors

To begin with, we trichotomized our reality into personal, social and natural realms, represented as concentric circles, from the innermost egosphere, through the middle sociosphere, to the outermost ecosphere. As social animals, humans exist within a local society, contained within the global supersystem, all of which ultimately exist within the natural environment. As social scientists, we are here primarily interested in the mesosphere, then in its relations with the outer macrosphere and lastly in the workings of the inner microsphere, ignoring the subconscious and supernatural as our dual externalities.

Since society (S) is a functional system, it has certain traits and goals (G), so that S either possesses or attempts to attain G. If S is moving towards its G, it is progressive or developing, whereas if it can maintain itself in a certain state in spite of all disturbances, it is stable or homeostatic.

Social systems always strive to attain and maintain some values, such as security, solidarity, stability. As dynamic systems, societies cannot be frozen in any state for any length of time (t), their equilibrium is therefore precarious, keeping itself within certain flexible limits. Any state should then be considered as a vector composed of a set of constants (a, b, c,...) and variables (...x, y, z). The behavior or flow of the system is a sequence of successive temporal states, all within the framework of its constitution that persists over time as its structural parameter.

Following our theory, we consider the PEC institutional sectors of the social system as our constants and their MED contents as our variables. Our simplified social model has three parametric sectors and variable flows in their various (ijklmn) subdivisions. It should be noted that PEC forms our three centers of power, wealth and status, whereas MED has been reformulated into the most significant flows along the interconnecting channels of the social system.

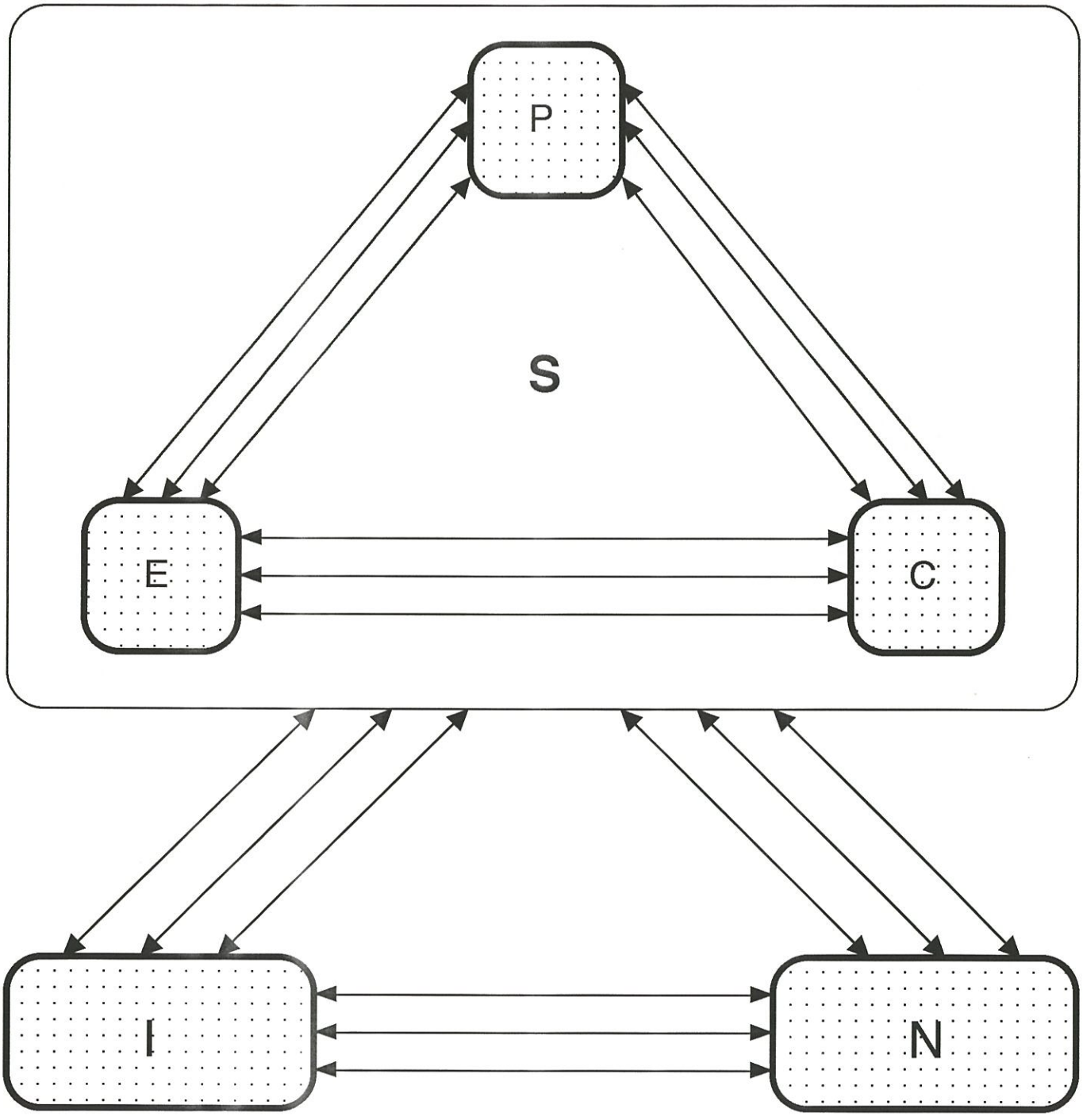
Thereby, the social state vector coordinates may be given as a bar equation:

	| Ei |	= various sectors i of economy E
	| Cj |	= " j of community C
SGt :	| Pk |	= " k of polity P
	| el |	= various flows l of substantive matter-energy e
	| dm |	= " m of influential information-data d
	| mn |	= " n of monetary convertible currency m

Finally, in order to distinguish these internal components and connections of the social system from its external ones, we have added the natural environment (N) and differentiated various social systems (S1, S2, S3, ...). As such, only the global supersystem (I) has a single planetary environment (N). Any particular local society or nation-state (S1) has a social environment composed of international relations with other societies (S2, S3,....), as well as its own natural environment (N1) within the global ecology (N).

These points are summarized in the following diagram that illustrates the internal PEC and external SIN connections of a particular society (S) with the international system (I) and its natural environment (N). The three double-headed arrows in each bilateral relationship indicate the MED (matter-energy, information-data, money) flows mentioned above.

PEC-SIN
TRILATERAL
SYSTEMS



XYZ
BILATERAL
FLOWS

2.1.2. Values

Ideologies are the main vehicles of social values that we may classify into:
-Economic control of wealth: collective vs individual; Capitalism vs Communism;
-Cultural expression of thought: unitary vs pluralistic; Liberalism vs Authoritarianism;
-Political participation of influence: democratic vs oligarchic; Populism vs Elitism.
The values of LIP (liberty, equality, fraternity) correspond to a combination of the above categories, which different regimes espouse in different degrees at different times.

In general, social change is a function of the difference between some given or ideal G* and some actual or real G distribution of state characteristics:
dG (s, t) = a[G*(s, t-1) - G(s, t-1)] dt, where a is the sensitivity parameter of the system. Furthermore, for social system S: dG (s, t) / dt = k (St-1) G (s, t), where k is a spatial parameter. This means that systemic behavior is a function of its structure; so by its very nature, the system constantly tries to bring its actual traits of G as close as possible to the ideal values of G*.

Finally, if we add the impact of exogenous variables N(s) and other unmeasured random disturbances r(s, t), then social change becomes:

dG (s, t) / dt = k(St-1) G(s, t) + bN(s) + r(s, t), where b is a vector of coefficients. Taking the limit as dt ---> 0, G(s, t) = kSG(s, t) + N(s)b = r(s, t). Thus completing the definition of a system's characteristics as determined by its structure in space-time, as well as its environmental interactions and other unknown factors.

2.1.3. Codes

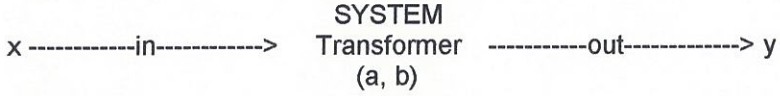
In addition to the state vectors and values of our system, we also need a set of rules for determining the values of G as a set of functions f relating the various components of S at different times t. Since science establishes functional correlations among several variables within certain parameters, a code is crucial to any model.

Mathematically, functional relationships are shown as equations of the form:
Gt = f(Ei, Cj, Pk, el, dm, mn) or simply: S = f (G). Clearly, these equations correspond to the state coordinates defined in the bar equation given previously. Systemic models thus try to account for significant events going on in a set of Gs and fs, since they compose the structure of S and its behavior in a time series of PEC snapshots.

In this sense, our model represents S in a particular context under certain conditions. This is shown by these mathematical equations as a functional identity between two variables. In this case the function is an ordered pair of elements, where the values of the independent variable G are equated to those of the dependent variable S; meaning that the kind of society we have depends on the interrelations and interactions of its characteristic components.

The simplest correlation between a dependent and independent variable is linear, as represented by regression equations between two variables and two parameters: i.e. y = a + bx; where y is the dependent or output variable, x is the independent or input variable, a is an intercept parameter, representing the expected level of y when x = 0 in which case y = a; and b is a slope representing the expected difference in y for a given difference in x, so that b = yi-yj / xi-xj.

This simple input + transform = output diagram illustrates the above equations:



Similarly, the same conversion process can be shown by a dynamic equation taking into account changes in time as: yt-yt-1 = a + b(xt-xt-1) or dyt=a+bdxt, in which case a will be value of y at the start and b=yt-yt-1 / xt-xt-1. Clearly, correlating x and y in either a spatial or temporal distribution is equivalent.

Adapting this general formula to social systems make it much more complex, because social transformations are not so simple as a and b. Yet something like: S = A + BG, where A and B are complex parameters, could serve as an adequate approximation of reality. It is this satisficing representation that we construct next.

2.2. FUNCTIONS

In addition to its structures, the social system also has certain functions, since social institutions serve some purposes. We hereby list these functions as the three flows of its circulatory system, along with their feedbacks and the regressions, as explained next.

THIRTY-SIX FLOW VARIABLES

FLOW	INFLUENCIAL (X)	FINANCIAL (Y)	SUBSTANCIAL (Z)
CP	Public Opinion	Income Taxes	Public Service
PC	Social Policy	Social Welfare	Food Aid
EP	Business Loby	Corporate Taxes	Nationalization
PE	Economic Regulation	Development Grant	Privatization
EC	Commercial Advertizing	Salaries + Profits	Donations
CE	Consumer Demand	Purchasing Power	Workers
IS	Foreign Pressure	Customs Duty	Imports
SI	Foreign Policy	Foreign Debt	Exports
NS	National Ecology	Gold	Raw Materials
SN	Environmental Policy	Conservation Fund	Waste Pollution
IN	Global Ecology	Earth Fund	Planetary Entropy
NI	Geology	Bullion	Natural Resources

2.2.1. Flows

The smallest units of a model constitute its components. These are the variables that we must now inventory and classify. Using the terminology introduced so far, the components of social system S are the PEC sub-system centers and their MED connecting channels.

As is well-known, any number of things (n) have a total of (r) relations, according to the formula: r = n2-n = n (n-1). Our three internal or external relations then add up to 6 for each context. Since we have 3 typical channels between them, we get 18 domestic and 18 foreign relations, with a grand total of 36 bilateral connections, as our circulatory system. From this total potential, the actual is less because certain channels may be empty in particular cases. Similarly, the carrying capacity and flow of each differs both in place and time.

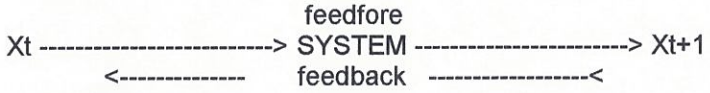
As the tabulation indicates, we are postulating that the three most important activities in the social system involve transportation (matter, energy), communication (influence, information) and exchange (cash, credit). These activities take place among the centers of political power, economic wealth and cultural influence, within and between social systems and their natural environment, as illustrated by arrows from one to another center.

On the basis of these structures and functions, we hypothesize that the way these various flows are distributed among the centers form the most significant macro-index of G in S. This means that the relative distribution and rate of flow in matergy, information and money within and between social and natural systems provide the best index of their political stability, economic productivity, cultural identity, national sovereignty and natural sustainability.

Most important, as the central hypothesis here, there is a definite correlation among matergy, information and money, so that one can be exchanged or converted into the others by the mechanisms of each system. It is our objective to find out how this conversion process works under different locations or conditions.

2.2.2. Feedbacks

An important class of systems, from the point of view of social science, involves feedback. It is through feedback that society is able to learn from its collective memory and history, if it can correctly interpret it. This attribute means that the output of one cycle becomes the input of the next and so on down the spiral, thus creating time loops of vicious, or virtuous circles.



The feedback process is represented by the change of x, which is: xt + dx = xt+1. The difference in dx is equal to xt multiplied by its rate of change: dx = r xt, where r = k dt. As each cycle is repeated, the value of t is increased by 1. Thus the traits of a feedback system at any particular time are a function of its history: Gt = fGt-n.

Societies are feedback systems because they build their future in a cumulative fashion by increments of their past. The mathematics of this evolution is by discrete time series. Although real time flows continuously, social events may be considered as distinct and separate phenomena with a beginning and an end at a particular time:

$$t = -n,...-2, -1, 0, +1, +2,...+n.$$

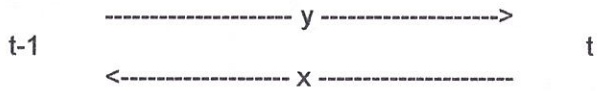
All feedback systems must contain some operation involving their past: xt = a + bxt-1. This first order linear equation goes one cycle only, so can be solved as: xt = a(1-bt+1)/1-b. For higher orders, the solution is the sum of all time periods in their history.

A most important consideration in feedback systems is how to maintain their stability and thus keep them from exploding as a result of positive feedbacks accumulating or compounding over many cycles. Destabilizing feedbacks are a well-known bane of social systems, as population explosions or arms races can attest.

Feedbacks can be handled mathematically by the slope parameter b. Whatever the exact feedback process is, we want it to counteract any exponential growth by compensating for positive feedbacks, so that the system retains at equilibrium. To do so, the absolute value of b must be less than

1: |b|<1, otherwise the system will self distract, either by imploding or exploding. In other words, systemic stability means that: dx/dt = 0 = a + bx or x = -a/b, thus stopping any further increases by stabilizing the value of x at the ratio of its parameters.

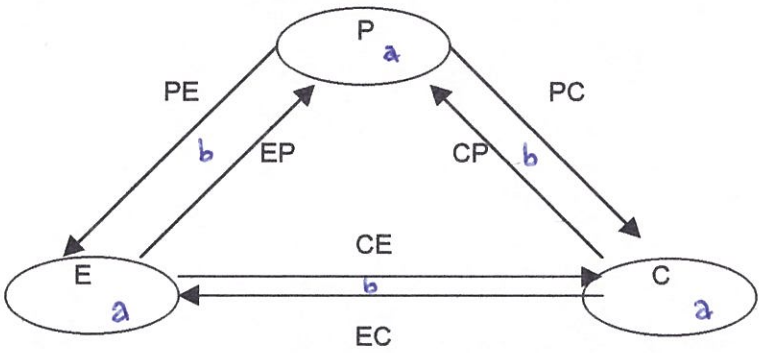
If to this simple-single self-feedback system, we add another one; we get the outputs of one system becoming the inputs of the other, thus forming a closed loop of continuous interactions, whose single first order cycle would be: yt = axt - byt-1.



On the basis of this explanation, we can next tackle the complete model of our social system, whose more complex structures and variables require multivariate analysis for their solution.

2.2.3. Regressions

In order to study the social system in any depth, we must consider its dynamics. In our model, this means the changes over time of the PEC centers and the MED flows between them. Since we have postulated linear relationships throughout, we can use regression equations to find out their history. But the previous bivariate formula no longer suffices because we now deal with three variables. In this case, multiple regression will be necessary to indicate how each center or sector interacts with the others. Let us take the internal workings of S and see how they look.



Each of these six arrows contains the three DEM flows that we designate as xyz. Taking them separately, we need three simultaneous equations for each flow to describe the total operation of this closed loop:

$$dxP/dt = aPxP + bCPxC + bEPxE - bPExP - bPCxP$$
$$dxC/dt = bPCxP + aCxC + bCExE - bCExC - bCPxC$$
$$dxE/dt = bPExP + bCExC + aExE - bEPxE - bECxE$$

Similarly, we simply replace x with y and z, to cover the other two types of flow. In any case, these equations mean that the values of PEC change according to the internal changes of each, at the rate of a, plus their inputs and minus their outputs at the rate of b.

The intra-subsystem feedbacks of PEC are contained in the a parameter and the inter subsystem feedbacks in the b, so in order to solve the net change of the system, we construct the determinant of the slope matrix as:

aPaCaE + bPEbECbCP + bPCbCEbEP - aPbECbCE - aCbEPbPE - aEbCPbPC =

$$\begin{vmatrix} aP & bCP & bEP \\ bPC & aC & bEC \\ bPE & bCE & aE \end{vmatrix}$$

The product aPaCaE represents the internal feedbacks of PEC;
The product bPEbECbCP represents the slope of the P-E-C-P loop;
The product bPCbCEbEP represents the slope of the P-C-E-P loop.

The remaining three negative terms are products of each internal feedback multiplied by the other two external ones. If one of the loops is broken, its slope b = 0, so its determinant disappears. Thus the conditions for stability are: S bii < 0; and |bij| <0; since the number of subsystems is odd for all loops.

2.3. PROCESS

In this last section, we are now ready to focus on the control process by which social systems may be governed. This activity combines systemic, cybernetic and politic abilities that are outlined below.

2.3.1. Systemics

We should first summarize our model by recalling the first structural diagram shown at the beginning. Its three concentric circles represent the most significant realms of our interest: in national social system (S) at the center; international supersystem (I) in the middle; and planetary natural environment (N) at the periphery. This SIN triad then forms our social world arena supported by its all-encompassing natural Earth framework.

Intersecting the first two inner social circles are their three (PEC) sectors: polity; economy; community. Of course, within each of these sectors, there are further subdivisions that go on as detailed as one wishes. It should also be noted that the strength of these sub-systems diminishes as we move from the national center to the international periphery, since the latter is not as developed as the former. Finally the MED contents of reality permeate all three realms as the matter, energy and information contents of the SET context of our universe of discourse.

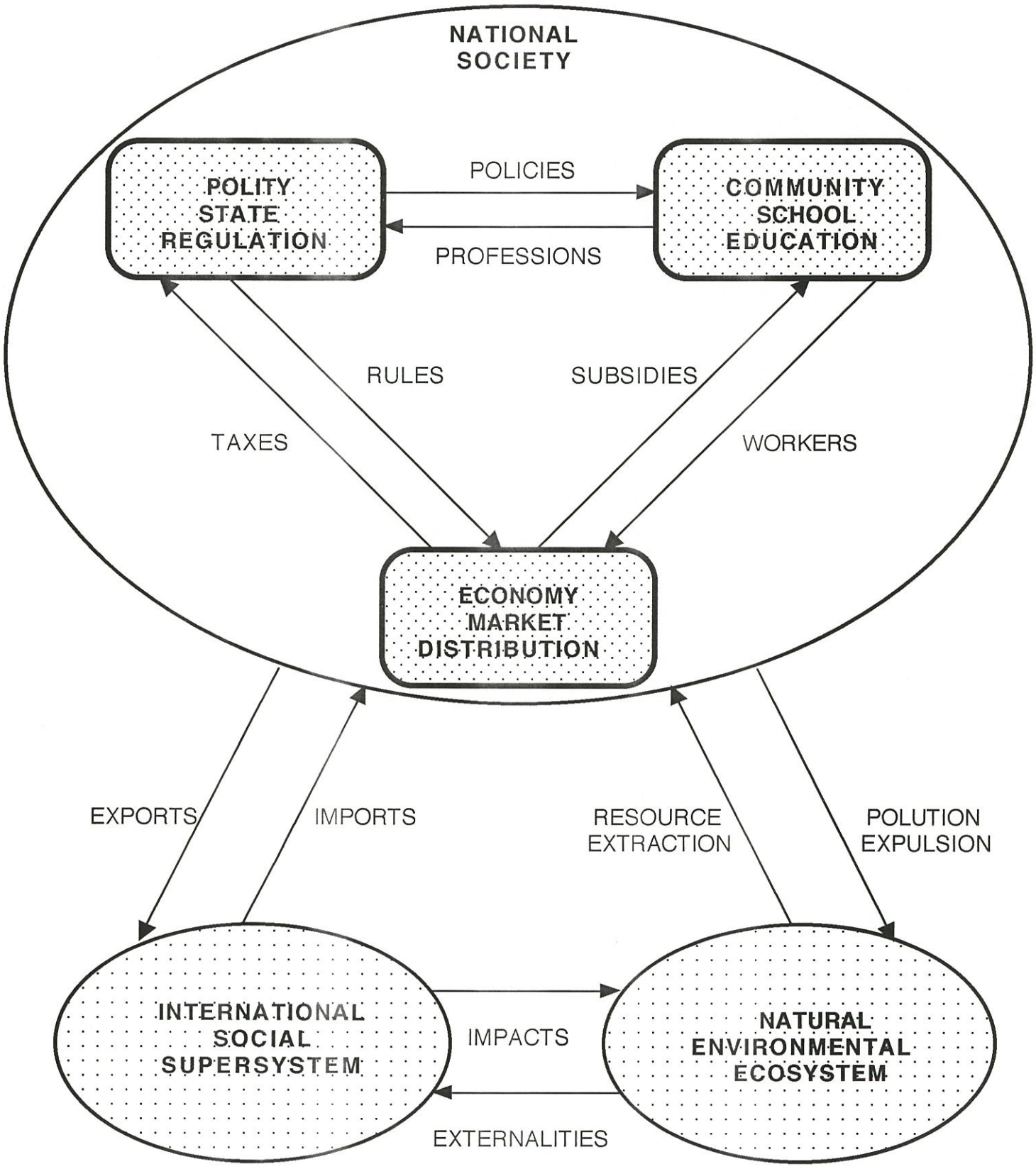
By introducing the external SIN supersystem to the internal PEC system, we could repeat our analysis of its formal treatment in the similar way. As our intranational system has three internal sectors, it corresponds to our external international system which also has the same number of centers. The same mathematics would then hold for either case. For this reason, we only need to discuss one of them and simply extend the same analysis to the other.

If we wished to combine the two, then we would end up with a PECIN pentagon and its 5x4x3=60 bilateral relations, instead of the 3x2x3=18 we have for PEC or SIN triangles separately. This geometric increase of interactions would complicate our model unnecessarily, so we omit it here, thus treating the two individually and equally.

The diagram below summarizes the above argument by showing both internal and external triads. This diagram is basically similar to a previous one showing the same configurations without the exemplary details of this one which are particularly suited to the triple helix paradigm.

(Global Universe)

THE GLOBAL TRIPLE SECTOR UNIVERSE



STRUCTURES-FUNCTIONS-RELATIONS

Matter-Energy-Information Flows

2.3.2. Cybernetics

Stability conditions for dynamic systems are not easily attained because it is difficult to balance diverse variables and disturbing factors. For social systems, destabilizing forces are due both to internal dynamics and external impacts. In simple societies, these forces may be handled in a reactive ad hoc way, but as systems become more complex and feedbacks more unpredictable, disturbances tend to multiply and get out of hand, so it is dangerous to leave them entirely to chance.

Consequently, modern societies need advanced cybernetic mechanisms to control social change more systemically and systematically. As cybernetics concerns the C3 (command, control, communication) of information, cybernetic systems are computatively intelligent mechanisms that develop explicit standards for normal behavior upon which their actual behavior is set. The comparative measure of the gap between ideal and real gives the magnitude of the instability that must be corrected if the system is to close the gap and approach normalcy.

The diagram below shows an ideal isolated social system that only has internal relations and interactions among its PEC sectors. On that basis, sociocybernetics try to bring actual performance as close as possible to the established norms, much as the thermostat does for ambient temperature. The difference between two states may be shown as: $dx = k(x^*-x)dt$; where k = parameter of systemic sensibility; x^* = desirable state; and x = observable state. Minimizing the difference in this general cybernetic equation as it applies to our system parameters, we have:

$$x^*P = b^*CPxC + b^*EPxE + a^*P$$
$$x^*C = b^*PCxP + b^*ECxE + a^*C$$
$$x^*E = b^*PExP + b^*CExC + a^*E$$

The three equations for the normal system state should be recognized as similar to the set of actual state equations given in the previous section. When we add the dynamic element to these static equations, they become:

$$dxP / dt = -kPxP + kPb^*CPxC + kPb^*EPxE + kPa^*P$$
$$dxC / dt = kCb^*PCxP - kCxC + kCb^*ECxE + kCa^*C$$
$$dxE / dt = kEb^*PCxP + kEb^*CExC - kExE + kEa^*E$$

This set of discrete difference equations are maintaining the standard format of the differential equation: $dX / dt = BX + A$, whose solution is found in the following determinant matrices, where starred items have normative values:

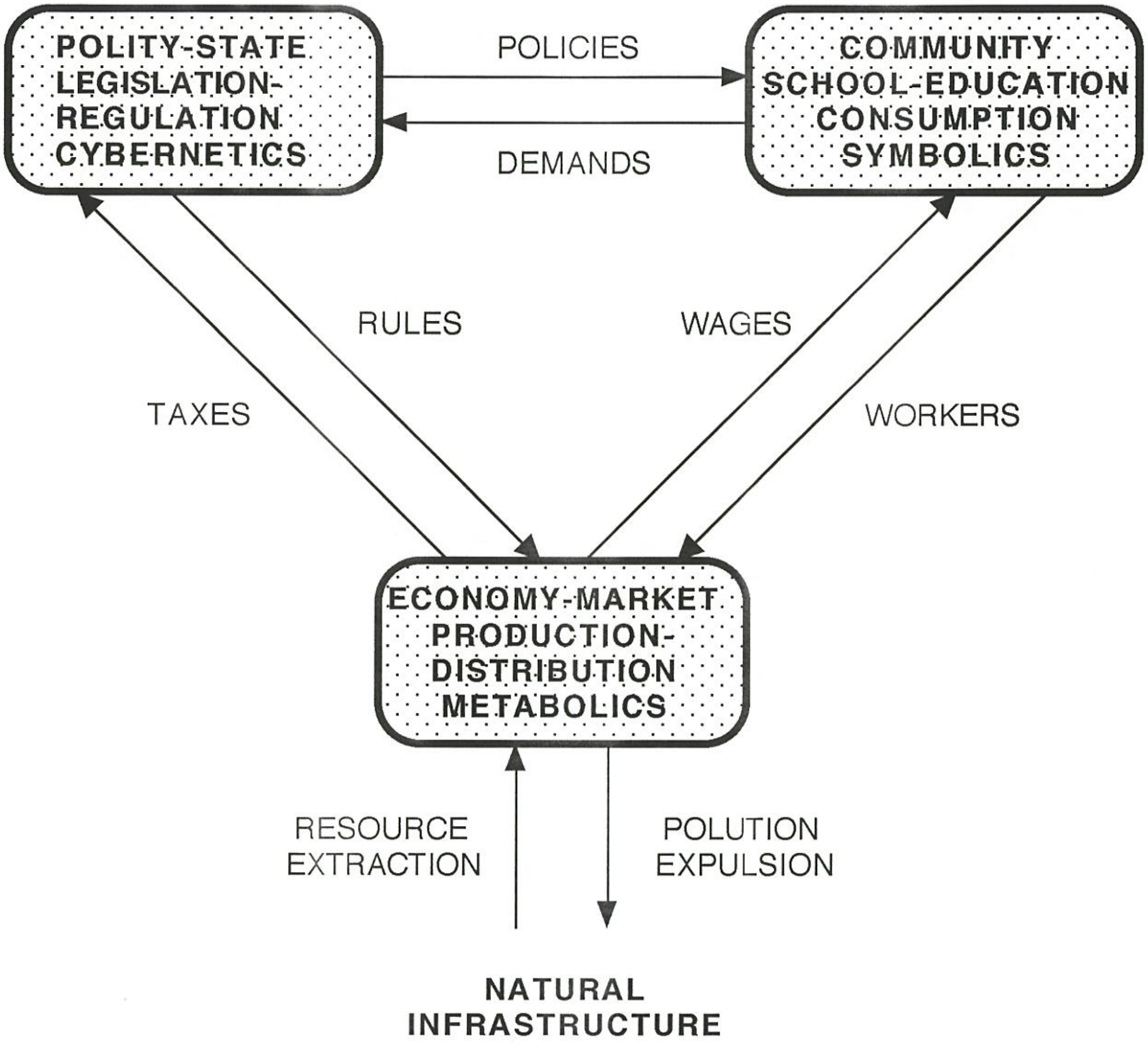
$$X = \begin{vmatrix} xP \\ xC \\ xE \end{vmatrix} \quad ; \quad B = \begin{vmatrix} -kP & kPb^*CP & kPb^*EP \\ kCb^*PC & -kC & kCb^*EC \\ kEb^*PE & kEb^*CE & -kE \end{vmatrix} \quad ; \quad A = \begin{vmatrix} kPa^*P \\ kCa^*C \\ kEa^*E \end{vmatrix}$$

This cybernetic process permits a quantitative comparison between the stated goals and measured performance of a system, given standardized indicators for them. Of course, similar equations to the above internal PEC system may be generated for the external SIN supersystem. Once these comparative evaluations are done, they can be used as inputs bringing an actual state as close as possible to its desirable one, thus bridging the gap between them as is the goal of any public policy.

(Isolated Society Diagram)

THE ISOLATED TRIPLE SECTOR SOCIETY

STRUCTURES-FUNCTIONS-RELATIONS



2.3.3. Politics

Complex systems are more structurally-functionally differentiated than simple ones. The social system's three PEC sub-systems are prototypes of such differentiation. Each of these sub-systems is a center where matter, energy and data are acceded, accelerated and accumulated. It is there where wealth, power and knowledge are constructed, converted and consumed.

These social activities are performed in different ways depending on the prevailing political regimes of these systems. In traditional *laissez-faire* societies, social values are determined and exchanged in a relatively "free market", whereas in modern "socialist" societies, they are more centrally controlled by public policies.

At present, all governments interfere to some extent in the operation of their societies in order to bring about a closer correspondence between their policy goals and the system's actual performance. The polity's intrusion into society in general and economy in particular therefore is a given in the contemporary world.

Although state incursions into national systems is a fact of modern social life, the international super-system is not yet so controlled. The rapid development of economic globalization has left behind the slow evolution of political and cultural integration of humanity. If anything, opposite forces to economic interdependence tend towards political independence. Sociocybernetic mechanists are thus in various stages of development in the various levels of geographical or historical evolution.

Our model accepts this situation in which the polity tries in different ways to impose some control in its society's internal and external affairs, by manipulating the levers of matter, energy and information flow among the relevant centers of power. Accordingly, we shall try to describe this cybernetic process by which government policies allocate influential or financial values into various social sectors.

The main instruments of state control are the government budget and public law or policy. Through the judicious imposition of positive inducements or negative impediments, such as legislation, taxation and subsidization, governments reward or sanction social behavior, thus maintaining or changing a system and its environment.

The diagram below illustrates how we see this sociocybernetic process, by opening what so far has been the "black box" of the political sector in our social system. The contents of the polity are now exposed to be of three types: material, financial, legal, corresponding to the x-y-z flows that connect the polity to the economy and society, as well as to the ecology.

At the input side, each of the incoming arrows feed into their switching mechanisms that receive and transform their flows conveniently into outputs and transmit them back into the system. For the x flows, the conversion is done by the institutions of the political sub-system, whose apex is the legislature Px. The door-keepers and power-brokers of these institutions receive, reflect or reject the various perceived influences (xCP, xEP, xIS, xNS), calculate their absolute and relative weight, thereby arriving at a net result which is promulgated as social (xPC), economic (xPE), ecologic (xSN) or foreign (xSI) policy.

Similarly, the various sources of government income (yCP, yEP, yIS) are pooled into the state coffers (Py), where they are reallocated to cover public expenditures according to budgetary priorities. The budget itself reflects government policy decided by the cabinet (DM) as the final central arbiter among the various political (Px), economic (Py) and social (Pz) exigencies. In this way public demands and supports in the form of taxes or duties, flowing in are transformed into into fines, subsidies or sanctions flowing out.

Finally, the state engages in certain direct matter-energy operations by nationalizing economic or cultural activities which bring in raw materials (zN) and transform them into finished products (zE). Of course, in socialist regimes this function is emphatic, whereas in capitalist ones it is atrophic. In any case, these flows to and from the polity may be shown mathematically by the following simultaneous equations, where g is the sensitivity parameter of the various political institutions:

$$xPC = gCPxP + gPC\ Px + gCP\ DM$$

$$xPE = gEPxP + gPE\ Px + gEP\ DM$$

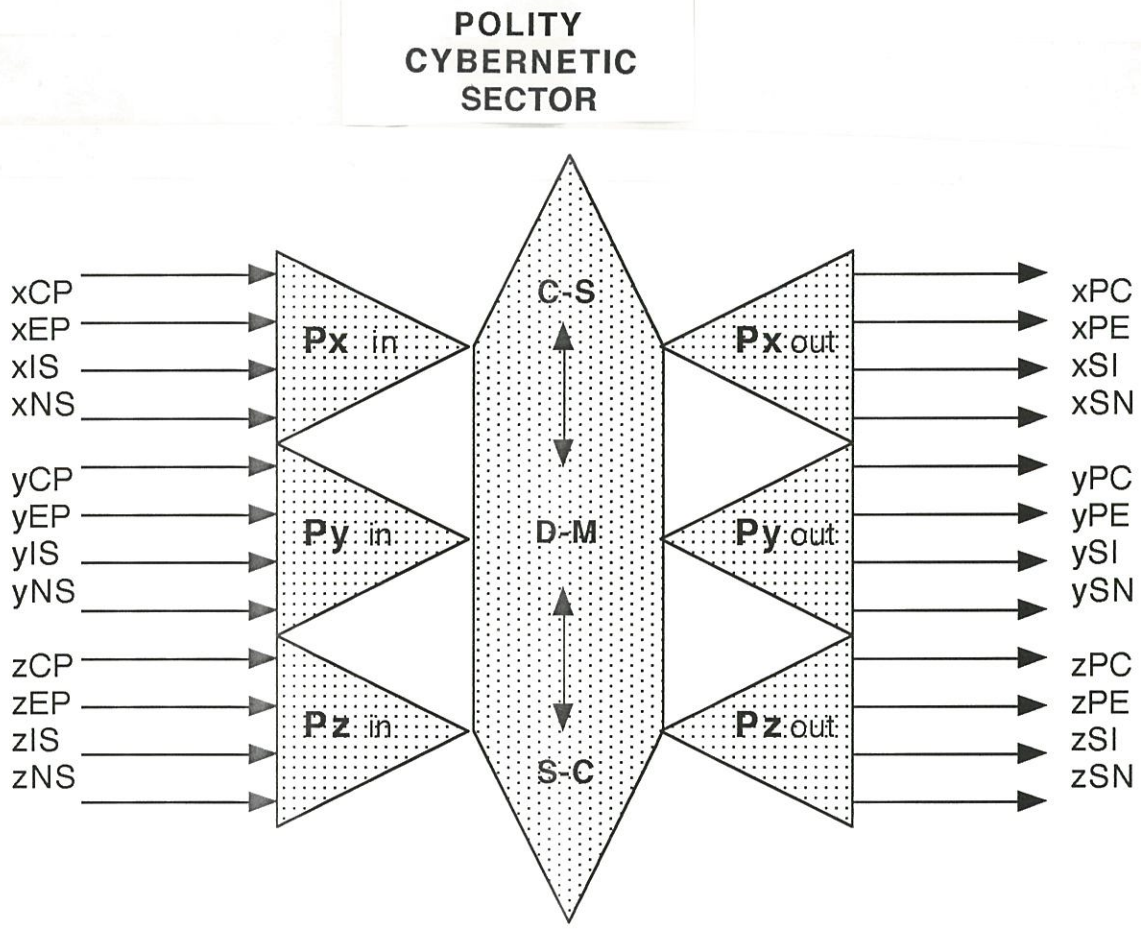
$$xS\ I = g\ ISxS + gSI\ Sx + gI\ S\ DM$$

$$xSN = gNSxS + gSNSx + gNS\ DM$$

Similar equations can be constructed for the y and z flows, as we have done above for the x ones. Moreover, in order to standardize the units of x, y, z, their flows should be calculated as percentage ratios, rather than absolute measures. This means that the sum of all x-y-z must amount to 100%:

i.e. Xip = Xpi = Ypi = Yip = Zpi = Zip = 1.

The principal functions of politics are thus to reallocate the relative portions of given amounts of money, power or goods in the social system and its environment.



SYMBOLS

x = Data-Information Communication
y = Money-Currency Transaction.
z = Matter-Energy Transportation

P = Cybernetic Polity
E = Metabolic Economy
C = Symbolic Community

S = National Society
I = International System
N = Natural Environment

D-M = Decision-Maker Executive
C-S = Civil-Service Administrative
S-C = Planning-Staff Consultative

Px = Legislative-Assembly
Py = Budget-Treasury
Pz = Operative-Agency

CONCLUSION

Since this is supposed to be the introduction of an ongoing project, the conclusion here is only a partial and tentative one. As such it simply highlights what we have done so far and sets out an agenda for the future.

The model presented here is structural-functional and takes into account the dynamics of social change in a trilateral system of three PEC foci and three MED loci, all operating within the SET context. Moreover, we have recognized the polity as the cybernetic mechanism of society and concentrated on the government as its central institution. Of course, it would be possible to select the economy or society for special detailed treatment, if we were particularly interested in industry or academy as our main function.

Having indicated the simultaneous equations relating the inputs and outputs through each sub-system's conversion mechanism, we constructed a formal model of sociocybernetics. The next step would be to operationalize these equations by quantifying the necessary parameters for their solution. This would require a determination of the PEC indicators for substitution in each item, with particular emphasis on the GIA triple helix within these responsive sectors.

More specifically, since we consider the state budget as the clearest index of government priorities, we have to compare its various items longitudinally to establish some trends whose average would set our parameters. Next we will have to see how the budget breakdown correlates with the distribution of interests and influences among the various social sectors, particularly industry and academy.

Here quantification becomes more difficult, since there is virtually no hard data on influence flows, other than public opinion polls. However, there are simulation techniques to generate such figures. These and other refinements should develop further this preliminary model and thus show the dynamics of a social system in its natural and cultural environment.

The ultimate challenge here and now is to find the proper dynamic equilibrium in the content of the state-market-school triple helix that applies in the context of any particular place and time.

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