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The Cybersyn Project as a Paradigm for Managing and Learning in Complexity

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ABSTRACT During the government of Salvador Allende, Chile implemented a paradigmatic system of control and regulation of production, emerged from the need of controlling and knowing the Chilean nationalized industry concerning the needs to provide.

Allende believed that the transformation pathway to socialism could be different to those that had existed, and he suggested a model of integration with the worker as the core of process management and decision making. In that sense the Cybersyn project was designed with the goal of having a decentralized state control of the industrial production able to attend real needs properly and timely. Starting on real-time information that would anticipate and correct potential incidents before they even occur.

The project provided valuable information on the nationalized companies for coordination and operation, being a political tool of vital importance for Allende's government for which decision-making issues reach the most proper level. Latin American current processes of social disruption allow us to analyze the historical perspective of this project to find parallelizing, similarities and common points that allow us to extend the analysis of industrial relevance of these cases. Furthermore, the current political, economic and social reality has evolve in such a way that the Cybersyn model requires an adaptation to new relevant complex features of the social system which challenge its practicality.

KEYWORDS Cybernetics, Democracy, Regulation, System, Management, Political Economy

1. A Paradigmatic case of managing complexity: The Cybersyn Project

1.1. Context: devising democratic socialism away from neoliberal roots

On September 4, 1970, Salvador Allende was elected president of Chile, his election was adjusted to the rules of the existing democracy. He presented himself as a candidate for the movement's Popular Unity (UP). He won with a margin of less than 2% on the next candidate, Jorge Alessandri Rodríguez. The government of President Allende would be determined by the decision to make deep changes in the economic model of the country. Allende outlined an alternative way to the classical construction of Socialism, called by him "democratic socialism." His approach advocated

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the use of institutional channels to take government power, and to act within the institutional framework as to modify itself. He questioned the approach of classical socialism, disagreeing with the overthrow of the state by using violence and ignoring the institutions of the old establishment.
At the time that Allende took office in Chile, the Soviet Union was in direct confrontation with the United States and The Cuban Revolution had taken place just a few years in advance. Latin America was close to a turning point that finally opted for the so-called "economic liberalism" but whose main characteristic is foreign interventionism and submission to the interests of finance capital, which strictly speaking would have nothing to do with classical liberalism.

The entrance of Allende as President of Chile was a clear message to the State Department of the United States, chaired by Richard Nixon: this country –Chile– would be closer to Soviet interests than to American ones.

As Allende arrived at the "Palacio de la Moneda", heassumed a difficult task: nationalizing a major part of the economy. He began to nationalize strategic sectors of the economy. Mining was the main objective of Allende, because of its large relative weight in the Chilean economy and its political relevance.

These politics were contrary to the dominant main, liberal economics, where the main objective is to achieve maximum benefit. Allende had an economic plan aiming at satisfying people's needs before corporate profits. He stated that the way to socialism was not the re-appropriation of local wealth in the hands of foreigners, but also abolishing the structure through which a few families held monopolistic industries. Hence, Allende was aware of the need to use all available technologies. Consequently the Chilean government has its first direct contact with the field of cybernetics in 1971.

In the first year of Allende, expansive Keynesian policies were applied, increasing wages, taxes, and expanding spending to stimulate economic growth, as a consequence the GDP grew over 7%, and production grew over the historical average. At the same time, they produced a rise in inflation and scarcity glimpses, logical consequences of a short-term economic restructuring plan of this type, but definitively not in the mind and large term. By the end of 1971, Chile had nationalized a significant number of the mining companies, and private industries. However, the plans were not fulfilled completely because most of the nationalized industries were not in the initial plans. The process required a consistent structure and delimitation of projects. The nationalization plan became a complex problem for the government.

Contradictions also emerged when the new directors were appointed. The growth of nationalized industry made the situation complex and difficult to control. In some cases, parts of the UP, complained that the new directors acted as their predecessors, and had a similar lifestyle - luxury life and despotism- which contradicted the principles of the UP government.

1.2. Looking for Cybernetic underpinnings

Fernando Flores, the technical director of the Corporation for the Promotion of Production (CORFO), the agency responsible for the nationalization of industry, knew the British cybernetician Stafford Beer due to his studies of the principles of cybernetics and operations research (Medina, 2006). Owing to the challenges faced by the Chilean economy Flores contacted Beer, and explained him the desire of the Chilean government to implement the principles of cybernetics in the government of the industry. Beer accepted immediately and started to work on this idea. By November 1971 he had his first meeting with Allende, where he outlined to Allende the scope and expectations of the project.

Beer had no higher education, but he had worked for a long period in the British steel industry. After World War II he joined as a laborer, became director of operations research. He studied cybernetics by himself and practiced this in the industrial sector, specifically cybernetics management, although he had retired from the industry to devote himself to academia.

After his contact with Flores he presented to CORFO the management system integrating the principles of cybernetics, this would be the Cybersyn ('Cybernetics' and 'Synergy') project seed. The system was based on Beer's ideas reflected in the book "Brain of the firm" where Beer described a "viable system model" which, according to Beer, "existed in all stable, biological, mechanical, social organizations... " (Medina, 2006). He argued that the abstract structure of the VSM was applicable to a large variety of contexts. The idea filled Flores' expectations and the work began. Consequently, Beer started to study the Chilean economy while the team that would create the Cybersyn project studied the book and the Beer's ideas of cybernetics.

1.3. The Viable System Model

This model "VSM" was grounded on the idea that the input variables of a system determine the state of the resulting system, and the number of possible outcomes determined the "variety" of the system. When the variables of the whole system were within normal value range it was known as a state of homeostasis, in reference to internal stability. It consisted of five levels, the first three levels were responsible for the daily operations, while the last two (systems 4 and 5) were responsible for the future development of the project in the direction of all enterprises (Medina, 2006).

The lowest level, *System 1*, is responsible for controlling the flow of raw materials, and production rates. Provide information about the input and output operations of the process based on the production system and local environmental information. *System 2* contained the information channels and bodies to complement and enable the transfer of information from and to the system 1. *System 3* represents the structures and internal controls to set the rules, resources and responsibilities of system 1, and to establish interaction with systems 4 and 5. Under normal conditions, the three basic systems could establish a complete management of the productive activity, while the highest level systems enter into stage only exceptionally.

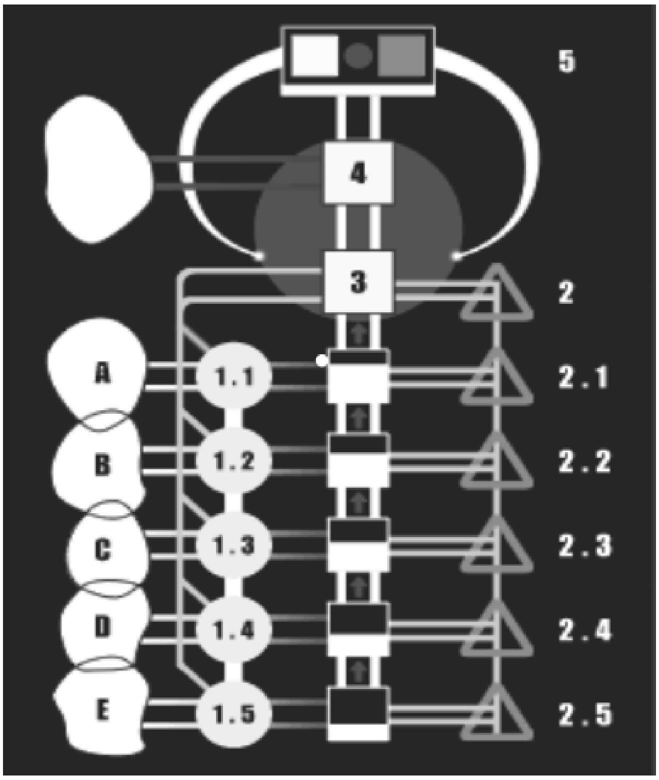

Figure 1: Schema of Cybersyn's Viable System Model.
The clouds on the left represent environments (A-E organizational, global at the top); 1: primary activities; 2: information channels 3: current internal management; 4: environmental and future monitoring; 5: political decisions of the organization aimed at balancing global necessities (OR-AM, 2006).

In system 4 relationships of the whole system with the outside were observed and feedback variables were reviewed, to be adapted appropriately to specific situations. Finally system 5 -the highest action level- was represented by the controller appointed to determine the direction of the entire company and the objectives of production. According to Beer, the 5-level model contained the basic outline of all viable systems. In turn he held that the entire system could be found at every level, "Brain of the firm" in biology is described as DNA replication found in all cells. He argued that the state, the company and the worker, all kept the same structural relationships. If you could design a theoretical model that worked out, it could be implemented from the most local level, as a section of an industry, to the presidency of the republic.

1.4. Deploying the Cybersyn Project

After having designed the theoretical model, they studied the computer resources available in Chile. By that time, Chile was one of the countries with lesser computing means in Latin America. The project counted with a network of satellite tracking telex and some computers. With these resources at hand they decided to use the network of telex to receive "real time" reports of the state of the industry in order to exploit a process of making really efficient decisions, thus industry regulation would serve the whole society and not interest of a few individuals. The idea of industrial coordination was, and is, paradigmatic. Production planning is certainly a highly complex task, requiring the coordination of thousands of people and the definition of variables and objectives aiming to meet the needs of a particular society. Trying to achieve it, Beer devised a measurement system that included variables from the levels of production and consumption to measure employee satisfaction in relation to absenteeism. With this system of variables, which were condensed into ten for each company, the status of each industry could be determined, and additionally each industrial sector could determine what the status of the entire state industry was. By controlling these variables each industry maintained a high level of independence, an idea that was fundamental to Allende. When one of the variables, at any level, indicated that there was a fault, a warning was triggered, so that the head of such level made the necessary corrections in a given time. If thereafter the failure were not corrected, the problem would be reported to the next level to be therein corrected. If it were still necessary, the system would raise the unsolved issue to a person appointed by the presidency of the republic.

The team used a telex network for communications between companies, sectorial committees, CORFO's management and government headquarters. The telex network operated under the logic of the current Internet, based on transmission at high speed rates, however, its poor communication capacity just supported a business-daily report, nevertheless at the time and for those resources, it represented a breakthrough.

Based on the same hierarchical decision-making model, the project as a whole consisted on four so-called sub-projects: Cybernet, Cyberstride, Checo, and Opsroom that emulate the Beer's "VSM". First, Cybernet was designed to use the telex network for real-time monitoring of each business. This control may seem contrary to Allende's idea of individual freedom, however, this control was limited to external observation, results per business day, which was framed in the idea of centralized economy. Cyberstride collected the set of software used for managing of Cybernet, to and from each of the state enterprises. CHECO, short for 'Chilean Economy' was never materialized, but it was a mathematical and statistical model sought to simulate the behavior of the Chilean economy as to predict it's behavior and likewise seek solutions before problems arise. Finally Opsroom was a space aimed at control the whole project. It consisted of seven chairs with simple systems for any type of worker could hold such positions. Opsroom was only materialized in a prototype.

Although the systems could not be fully implemented, in October 1972, the Cybersyn team faced the truck strike – supported by the CIA and the US 40 Committee (Church, 1975). Cybersyn endeavored organizing the 200 loyal truckers (against 40.000 in strike) to warranty the most essential transports. The survival to this crisis made the project respectful. Furthermore, Fernando Flores, who together with Beer and Raul Espejo had directed the project, was appointed as Economic Minister. Nevertheless, the project could not be fully developed because the offensive to turn back the transformations introduced by Allende's government ended with the coup of 9/11 of 1973. At that time Allende had ordered relocating CORFO's headquarters at the "Palacio de la Moneda" trying to materialize the completion of the project, but the bombs and shots falling down the Palace tragically ended the experience. Pinochet's military command did not understand what all that could serve for and decided its immediate dismantling. Subsequently Flores spent three years in the concentration camps of Pinochet's Chile (Rivière, 2010).

2. Managing and knowing in globalized complex scenarios

2.1. Beyond Cybersyn: actualizing the VSM

Considering now the Cybersyn project as paradigm to the management of complexity[1], it is at this point important to bear in mind the significant changes that have been produced since in the international economics, politics and societies. This makes necessary the actualization of the system approach depicted by Beer's VSM —s. fig. 1.

As it has been discussed by one of the authors (Díaz Nafría J. M., 2011), the concepts of social security and national security to which Cybersyn project could be linked, requires a fundamental shift from the context of sovereign states as the level for the attainment of security—in which Cybersyn was deployed—to the complex societal system of global relations, which is in turn bounded by the Earth ecosystem.[2] Furthermore, the tragic ending of the project and the external interventionism probes the need to attain security at these contexts, conceiving as an international endeavor the security of the complex societal system from the perspective of tracking goals shared or fitted to the global functioning of the entire system.[3]

At first glance, a system to manage complexity—in the sense posed in (Díaz Nafría J. M., 2011) as mostly adequate for the real complexity of social system and its long-term sustainability—embraces the following features:

(1) Related *systems* are open, though ultimately closed by the biosphere, and cognitive. The earth ecosystem within its stable limits—i.e. the set of states within which any variation is reversible—sets the ultimate boundaries of any other system. Its feed of low entropic energy sets the limit of available energy; its capability to release high-entropic energy limits the affordable waste.

(2) System's *ontology* is defined by the set of components, structure—identified by relations among components—, and the environment in which it is immersed; System's *pragmatics* are defined by the set of functions and acts within the environment in interaction with other systems;[4] System's *epistemology* is defined by the complexity and state of the cognitive subsystem.

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[1] Example that could well be accompanied by the projects developed within the context of the DDR-Cybernetics since Klaus' proposals in the 1960s, particularly as carried out since the mid of the 1970s (Banse, 2015).

[2] As briefly discussed above, the VSM was intended to cope with complex societal systems, and the level 4 was intended to cope with environmental needs and limits in a long-term basis. However, the complexity of the societal system is now of higher order and the closure of the ecosystemical dimension is now tighter linked to the biosphere.

[3] The interventionist dimension of the US concerning alleged threats to their interests can be unambiguously observed in the Church Report of the US Senate (1975), "Did the threat to vital U.S. national security interests posed by the Presidency of Salvador Allende justify the several major covert attempts to prevent his accession to power? Three American Presidents and their senior advisors evidently thought so." Due to its international character, it unveils the dominancy criteria in US security issues.

[4] The interaction with the environment and with other systems is distinguished because often the functional linkage among them makes the interactions particularly relevant with respect to other elements of the environment not functionally linked with the system. These interactions usually serve to some heterarchical organization.

(3) The *security* of a system at any level refers to the stable attainment of a sufficiently broad space of possibilities in which the system can cope in the long-term with environmental dynamics and its own necessities.

(4) The *space of possibilities* (or space of freedom) is defined by the region of the state space of the system in which the system can freely vary through alternative paths causing subsequent limited changes to the related systems (especially those at higher or at the same level).

Figure 2 provides a basic schema of a system in simple interaction with the environment. The diagram stresses the relevance of the information phenomena in (i) steering the system; (ii) interacting with the environment and other systems; and (iii) actualizing knowledge about the environment, other systems and the system itself.

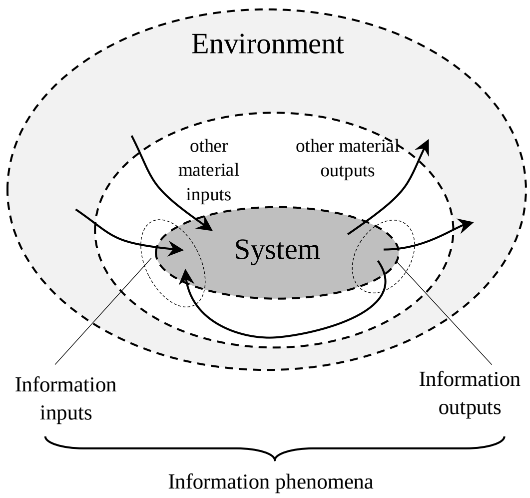

Figure 2: Simple system model of interaction with the environment.
The dotted boundaries stand for the fuzziness of the system's limits. An outermost defined and closed boundary could be considered at the biospherical level in which the interaction with the outside is in the form of a low-entropic energy input and a high-entropic energy output. This model can serve for hierarchical systems in which lower level systems are nested.

But these elements alone do not enable to cope with the complexity of the global societal system closed by the Earth ecosystem. Thus some new characteristics have to be added:

(5) *Sustainability*: the limits and the space of renewable resources of our natural environments set the first space of freedom for the social systems. These have to accommodate their set of necessities and set of acts (including production) within the natural space of freedom to keep it balanced. Furthermore, this balance has to be attained before the point of diminishing returns in which adaptation becomes increasingly problematic, namely its *carrying capacity* (Street, 1969) (TurnerII, 1997). Similarly, any social or technical system nested in another of higher order has to accommodate into the social space of freedom.

(6) *Heterarchical organization*: As pointed out in section 2.3. instead of hierarchical systems, in which lower order systems are nested into higher order ones, the actual complexity of societal systems rather corresponds to heterarchies in which the component subsystems might belong to several systems. This is for instance the case of nervous systems, as first studied by McCulloch (1945). Since the relations of the parts of the heterarchy to one another are unranked or "possess the potential for being ranked in a number of different ways", this organization clearly challenges the Cybersyn model of fig.2, and increases the space of non-equilibrium to which security is concerned (Bondarenko, 2007).

(7) *Fuzzy system limits*: A further problem regarding a proper grasping of the systems concerns their blurred limits (for instance, in the linguistic systems there are always elements that are in process of being incorporated to the flow of the used language; some others that are being lost, and finally others whose functions are changing). Although this issue is of higher relevance in the systems that are being formed, or are dying out, to some extent, this is the case of any system (even in the technical ones, in which often many characteristics are inherited by older configurations, have a diminished functionality, and they will be eventually removed). In our plea for a scenario of emancipation, this regard is fundamental for envisaging the enabling of new systems to appear (De Paoli, et al., 2011)

Though all this makes the systems difficult to model and analyze (the given references provide some guidelines and proposals to do it), something remains easy to distinguish: if the system is secure within its environment, it is in a quasi-stable condition, and the reactions to changes in the environment tend to compensate those changes. Nevertheless, if the change in the environment is significant the system may try to adapt itself through the identification of suited environmental conditions and the development of new functionalities with respect to managing the complexity of the new scenario.

As system theory and practice has proven, if proper relations are envisaged and procured, the stability of the system can be evaluated and (parametrically) granted (as the Cybersyn project showed), even though its particular dynamics (i.e. its evolution, its history) cannot be predicted since it properly depends on the free elections taken by the members within the space of freedom.

2.2. Information and cognitive boundaries

As discussed elsewhere (Díaz Nafría J. M., 2011) managing complexity involves objective and subjective values, the former concerning the actual state of the system and the environment, the real system's leeway, and its dynamical relation with the environment. But determining what is relevant, and trusting in such knowledge are both subjective. The difficulty to reconcile them concerns—among others—the fundamental difference between the outer and inner perspectives, which presupposes a different ontological and epistemological position through which cybernetics has historically moved (Díaz Nafría & Pérez-Montoro, 2011a). Ontologically because we form part of the system we are interested in; epistemologically because we cannot observe the point from which we observe. Furthermore, the openness of the systems (represented by dotted lines in fig.2) implies that even if we observe the environment, our possibility of modifying it makes that the combination of environment and system forms a system of higher order, and we actually steer both at a time - though in a different degree. Thus the goals of a system have to be immersed into the ones of the higher order system.

This means assuming a common ground of what has been called second order cybernetics: the objective and subjective perspectives are mutually dependent and the system cannot be clearly separated from its environment, as it happens in living systems and even more in human and social systems.

One of the consequences of this limitation—namely the unfeasibility of a neutral observation—makes the scientific certainty concerning stability out of reach. Thus, managing complexity can only be granted to a given extent and needs to be constantly re-actualized while the system is steered in relative equilibrium with the steering of the systems of the higher and same order, i.e. within the whole complex societal system closed by the Earth ecosystem. It is easy to see that this idea is actually not very far apart from the concept of the Cybersyn's Viable System Model.

But to this point, it is worth delving into the characteristics of our awareness of the environment upon which the steering of the system for security attainment is founded. As we have analyzed elsewhere (Díaz Nafría & Pérez-Montoro, 2011a), (Díaz Nafría & Pérez-Montoro, 2011b), (Al Hadithi & Díaz, 2010) the awareness of the suitable conditions of our environment is constitutively limited and blurred in virtue of the physical nature of the manifestation of reality. This means that in order to assess the environmental conditions and to foresee future conditions, we must deal with:

(1) The open character of the reality being sensed;

(2) The limitation and fuzziness: 1st, of the manifestation of such reality, 2nd, of our awareness of reality, and 3rd, of our knowledge.[5]

Using the concept of information posed by the GTI, the process of awareness can be studied by means of the action of information upon infological systems and the triadic relation established by the Environment, information and the Infological system (Burgin, 2010). From our analysis of the dimensional relations among the parts of this triad (Díaz Nafría & Pérez-Montoro, 2011b): the maximal complexity of an observed system has one dimension more than the maximal dimension of any informational process related to the observation (e.g., if observing in a three-dimensional domain, the information is two-dimensional, while observing in a space-time domain the accessible information is three-dimensional). Thus we have to conclude the imponderability of the knowledge base with respect to the weight of information in the whole awareness process, since it is upon this base how the missed dimension can be restored.

The role of the social assets corresponding to the cultural and scientific base, education, and research has to be brought to the forefront in order to unveil its value in the economics, and in the attainment of social security. Moreover, as underlined in the previous section, a fair and participatory society requires keeping those assets in the public sphere circumventing the appropriation by the private sector.

But considering once more the aforementioned limited, open, and fuzzy character of our awareness and knowledge, it can be pointed out that the *infological system* modeling our cognitive process, or serving as a control mechanism for steering the system should correspondingly keep these characters. Therefore a fuzzy and paraconsistent calculus (adapted to the reality of our knowledge) based upon the information grasped should drive the complexity management the societal system (Al Hadithi & Díaz, 2010), (Priest & Tanaka, 2009) Far from being a hindrance to the achievement of quasi-stability, this kind of control has shown a higher degree of robustness (Al Hadithi, 2002). Furthermore, the posed limitations of our knowledge and awareness of reality implies—beyond a permanent adaptation of our knowledge base to the attained evidences—that our balance of necessities and resources has to be permanently actualized and reviewed by an ethical and critical concern for all social interests and their related threats in a sustainable horizon.

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[5] These structural ambiguities of reality, on the one hand, and our sensible intellection of reality, on the other hand, have been studied from physical-mathematical, biological and cognitive perspectives (Díaz & Pérez-Montoro 2011a, 2011b, Díaz & Hadithi 2010b).

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