# Exploration of the relationship of viable systems, identity, and environment: extending the bionic analogy

Camilo Osejo-Bucheli

https://doi.org/10.1590/SciELOPreprints.5410

Submitted on: 2023-02-26
Posted on: 2023-03-06 (version 1)
(YYYY-MM-DD)

# Exploration of the relationship of viable systems, identity, and environment: extending the bionic analogy.

Camilo Osejo-Bucheli[1]

https://orcid.org/0000-0002-6712-6228

Email: camiloosejo@udenar.edu.co; camilo.osejo@correounivalle.edu.co

[1] Universidad de Nariño, Universidad del Valle.

**Abstract:** The article deals with the problem of the relationship between identity, the environment, and viability, discussing evolution in viable systems. On a logical structure of argumentative analysis, the article uses cybernetic, and evolutionary theories, for suggesting the way the environment shapes systems. It presents the idea that viability in systems is the result of the selective forces of the environment on the identity of systems. The extended phenotype analogy is presented and explained for viable systems. It suggests the idea that viable systems adapt to their environment. It presents and discusses different adaptive strategies for viability. The idea that viability in systems is related to evolution is not new, but this paper is innovative in the sense that it presents a relationship between viability, environment, and the identity of viable systems. The paper has implications in the understanding of viability in viable systems theory that involves reproducibility, adaptation, identity.

**Keywords**. Viable system model, evolution, adaptation, environment

**Conflict of interests**: The author declares not having any conflict of interest regarding employment, voluntary involvement, collaboration with any institution, organization, advocacy group related in the content of the manuscript, the author declares has not received any grants for this research but is an academic leave from the institution he is currently working for; the author has not received any personal fees (eg, honoraria, consulting fees, lecture fees) for the production of this manuscript, the contents of this article does not infringe any intellectual property (eg, patents, copyrights, royalties), the author has not received, nor he owns stock or share ownership of the source of destination of this manuscript, or the content of the manuscript; the author does not benefit from the development of products related in the manuscript; the author has not received any Gifts (eg, drugs, equipment, tools, software) from any source in the manuscript, the author has access to data repositories through the institution he is affiliated with only; the author does not hold nor any position on boards is dependent upon this manuscript, the author has not any close relationships with editors at the journal; the author does not pursue any political interest with the publication of this article

## 1 Introduction.

The viability of organizations over time was Stafford Beer's main concern for the formulation of his theory on management cybernetics. The intent behind Beer's Viable Systems Model (VSM) was to determine the most appropriate organization to ensure the viability of the system. Today, the model has been widely developed and applied, and it has been observed that although the model does indeed increase feasibility, some systems are better adapted for some environments than others. If we look at nature, it is possible to show that some organisms are better adapted to some environments than others, but in turn, environments guide the form and functioning of systems.

Beer (1994) mentioned that viability allowed the evolution of the system, but never explained in detail how viability and evolution are linked. In fact, Beer uses the term evolution with several different meanings in *The Brain* of the Firm, but on a handful of occasions, the term is used unequivocally to denote the theory of evolution by means of natural selection. Many cyberneticists are of the opinion that the theory of evolution by natural selection is inconsistent with conscious decision-making of the VSM through its System 5. We believe that thinking that a viable system is not a product of the environment would imply that it cannot evolve. In the following lines we will discuss the classic literature of the subject and establish a relationship between viability-evolution-identity to finally establish the relationship of viable systems with the environment.

The hypothesis that motivates this article is whether, as in biological systems, the environment could dictate: the structure, form, functioning, and viability of systems through natural selection, acting on the identity of the system. In our research some articles leading to this hypothesis have been accepted for publication.

It is hoped that this work will clarify the relationship environment-identity-feasibility. This article dealing with viable systems is aimed at practitioners in management cybernetics and academics in applied systems theory. So, although in the literature on systems we talk about environment, and in the literature on biology we talk about environment, here we will use both terms interchangeably.

For this, the article begins 1) by recalling the neurophysiological analogy of the VSM, and then proposing 2) a cybernetic model of the evolutionary algorithm, which can be applied to viable systems. Later 3) extends the analogy between adaptation in natural evolution, and the unfolding of complexity in viable systems. It presents 4) the idea of the extended phenotype to show that the identity of an organism alters the environment, and 5) we finally propose a model of the interaction of systems with the environment.

## 2 Method.

## 3 VSM bionic analogy

The viable system model is a cybernetic abstraction of a system adapted for feasibility, an arrangement of parts that allow the system to deal with complexity cohesively. Beer (1972) concludes that the network best adapted for viability is the human nervous system depicted in Figure 1.

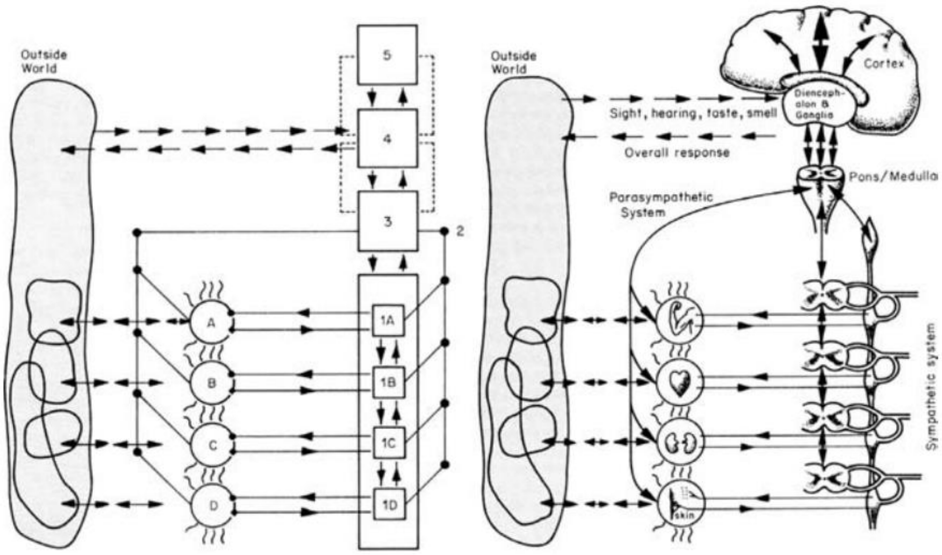


Figure 1 – Neurophysiological model of ACV. 1*Source:* (Beer, 1972, págs. 130-131)

It is not unexpected that the analogy of the organism has gone further in the identification of subsystems in the ESV like those of the human body (see Table 1). The relationship between the parts of the environment and the parts of the system is present one by one even at the cellular level. This sophistication is an evolutionary adaptation to changing environmental conditions. (Espejo, 2004)

Table 1 – Subsystems in the VSM and nervous system. Source: adapted from (Vahidi, Aliahmadi, & Teimoury, 2018); (Walker, 1991, p. 8.9) .

| **Sistem** | **Analog definition.** |
| --- | --- |
| *Sistem 1* | System 1 represents basic and primary activities. It is composed of all units of the organization that perform operations in practice and is analogous to the muscles and organs of the human body (Dominici & Palumbo, 2013). |
| *Sistem 2* | It is analogous to the sympathetic nervous system that stabilizes the activity of muscles and organs and ensures that their interactions remain stable. |
| *Sistem 3* | It is the base brain, the medulla, that oversees the entire complex of muscles and organs and optimizes the internal environment through thorough evaluation. It optimizes the collective operations of the muscles and organs of the body through a thorough examination. In addition to carrying out System 2 functions, System 3 is also responsible for finding ways to generate synergies between operating units. (Beer, 1994). |
| *Sistem 4* | It is the Middle Brain, the Diencephalon that connects to the outside world through the senses. It is analogous to the human conscious nervous system and looks at the environment, collects information and makes predictions. Adopts the necessary strategies and plans to have an optimal adaptation to the environment (Espejo, 2013). |
| *Sistem 5* | It is analogous to the cortex of the brain and the functions of the upper brain. It defines the identity of the system and its general vision or raison d'être. This system decides what policies and operational guidelines the system will follow. (Beer, 1994). |

Having recalled the bionic analogy of the VSM established by its author, we will proceed later to propose an extension of it. To relate it to the evolutionary algorithm that we present below.

# 4 Evolution by Natural Selection as a Cybernetic System.

## 4.1 Evolutionary algorithm in nature.

Evolution is a continuous and gradual process without a specific goal. It follows a circular replication-variation-selection algorithm (Figure 2). Bateson (1991) recognized that "reciprocal causality", or cybernetic feedback, is preferred by evolution (p.306). Although in a circuit, by definition, there is no starting point, we will begin by presenting the evolutionary algorithm with replication.

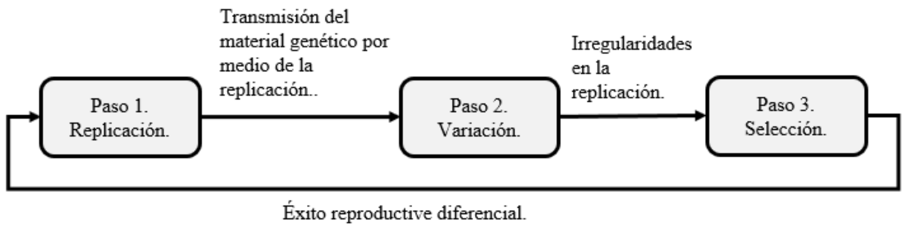


Figure 2 –evolutionary algorithm.

Replication is a generator of complexity and adaptation. In nature, replication is synonymous with reproduction. Reproduction is carried out only by individuals of one species, which have survived to reproductive maturity. Likewise in the sexed species, only those individuals considered suitable to procreate by the opposite sex manage to transmit their genes to the next generation. During reproduction, the genome of two individuals of the same species combines to generate imperfect copies of the parents. The physical characteristics that made parents successful in survival, and replication, are inherited by their descendants.

Variation happens during replication. The descendants retain only about 70% of the genome of their parents, the remaining 30% is completed with a random variation within the identity parameters of the species. Variation will produce individuals who retain the physical characteristics that ensured the viability of the parents but are different enough to have their own identity. This enormous variability within the same identity of the species allows individuals potentially adapted to the variability presented by the environment to appear. (Dawkins R. , 1976)

The selection process exists when individuals fail to survive to their reproductive age. Or when within the same species individuals with some particular physical characteristics are favoured in reproduction. In the selection process, the genetic material of individuals who fail to transmit it to the next generation is lost. Those who adapt to the environment, achieve differential reproductive success, that is, they have the opportunity to produce individuals similar to them. Evolution is an enormously destructive and wasteful process. (Dawkins R. , 1976) (Dennett, 2009)

So far, we have introduced the evolutionary algorithm, then extend the bionic analogy to systems. The following title proposes a cybernetic model that can provide a better understanding of evolution in viable systems.

## 4.2 The evolution in systems.

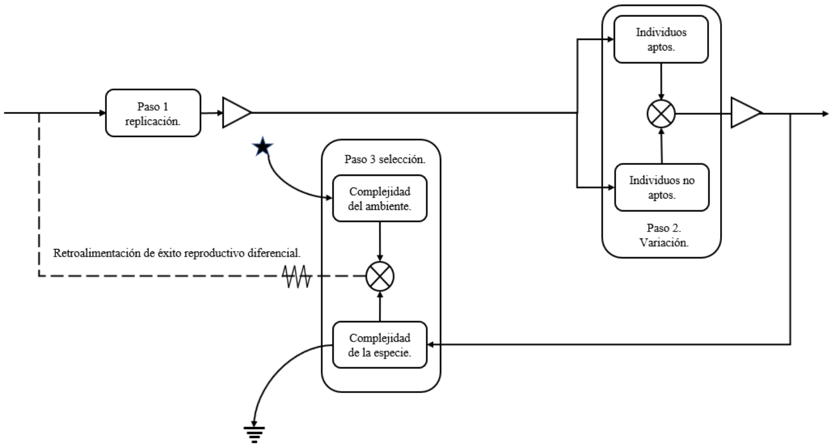


Figure 3 – Cybernetic model of the evolutionary algorithm. Source: this research.

In natural systems, the characteristics that make a system successful viability are replicated in the next generation.

Beer (1989) clearly understands that the acquired characteristics of individuals cannot be inherited, that is, if a lizard loses its tail, its offspring will not inherit such a characteristic, however, in social groups if there is an inheritance of acquired characteristics. Beer believes he has discovered a limitation of ACV. We will return to this discussion later, proposing a solution.

> "A major battle in biology concerning the possible inheritance of acquired characteristics in the individual, as conceived by Lamarck, seems to have been

> settled in recent years by microbiologists. There is no such inheritance, for genetic information is always carried by nucleic acid to inform the protein molecule – and never the reverse. In society, however, that is in the social group, there clearly is an inheritance of acquired characteristics. Therefore, a major difference emerges as between the VSM of the individual and the VSM of society to constitute, at least on first sight, a limitation of the model." (Beer, 1989, p.9)

Reproduction as seen from Distant Equilibrium Systems (SFE) is a combination of genetic information (Tyrtania, 2008).

As in natural systems, variation produces systems that at the same time retain the characteristics necessary for the viability of the original systems, and the identity characteristics themselves. This variation generates an identity within another identity, which is consistent with Beer's (1989, 1992) idea of recursions. From the SFE, Adams (2007) understands that combination and variation produce differentiated "systemic structures", adapted to different environments. (Adams R. , 2007) This means that there will be individuals adapted for one environment and not suitable for another. In our model, we represent this variation by the comparator (⊗ ). The comparator means individuals adapted for different environments that form the complexity of the species, and that is also why an amplifier is presented after the comparator.

When a system does not have the capacity to present the variability required to match the variability of the environment, it enters a state of unviability, that is, it is unable to adapt to the conditions of the environment. Even in reference to SFE, Adams (2007) recognized that, like living beings, they do not replicate in the next generation. The less favoured is eliminated from the gene pool. (Adams R. , 2007)In our model, the inclusion of variability in the environment is shown, and the symbol (  ) can be understood as the energy contained in these organisms returning to the environment when they "disappear". That is why, there is an attenuation effect after the comparator that equates the complexity of the environment, with the complexity of the systems, in our model.

Our model shows that the adaptation of systems is guided by the environment during selection. Next, we consider the way in which Beer (1972, 1992) conceives the idea of adaptation to the environment.

## 5 Adaptation, Variability Absorption, Identity: Result of evolution.

This title extends the bionic analogy, now, with respect to adaptation to the environment.

### 5.1 Adaptation in the Natural World.

In living organisms, the environment determines not only the development of their physical characteristics, but also the behaviours related to energy expenditure, and the life cycle of the creature (Dawkins R. , 2010). Thus, agencies specialize to adapt to environmental conditions and competition for resources. Figure 4 shows the adaptations of the Finches observed by Darwin in the Galapagos Islands. These subspecies have adapted their beaks to different diets available in the environment.

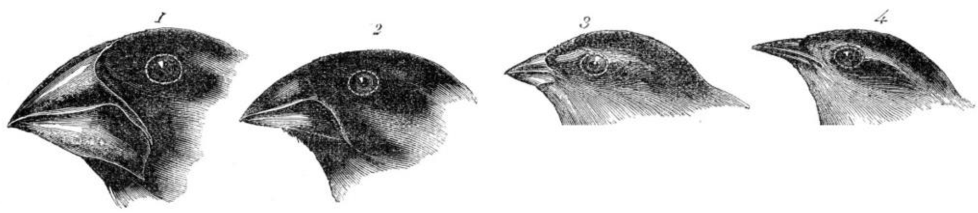


Figure 4 – Finches of the Galapagos Islands. *Source*: , public domain image. (Darwin, 1885)

Energy efficiency dictates specialization in living systems. The greater the specialization of animal species, the greater the differentiation between them. And, the older the common ancestor between two species, the more differentiated they are in biological taxonomy. (Adams R. , 2007)

## 5.2 Bionic Analogy of Adaptation in Viable Systems.

Systems adjust their cohesion to the complexity of the environment to achieve the required viability. Beer (1994) equates this adjustment with control mechanisms. An example of this is the regulation of the internal temperature of the body to compensate for changes in the external climate (Espejo, 2004). This adjustment is also presented by the immune system, which adapts to the environment in which the individual lives in an autopoietic dynamic (Tyrtania, 2008). The adaptation process is considered an autopoietic or "operational closure" process (Maturana & Varela, 1997 [1973]).

The increase in individual variety allows systems to cope with the greater variety of the environment (Ashby, 1956). Therefore, a system has the required complexity, when there is a complexity comparable to that of the environment (Espejo, 1989). The adaptive strategy for dealing with overly complex environments is to disaggregate environmental complexity into manageable portions of it and allow autonomous subsystems to interact with comparable complexities in the environment. This process makes viable systems adapt to highly uncertain environments, incorporating "autonomous systems within autonomous systems" (Espejo, 1989).

Other systems deal with complexity in different ways, traditional hierarchies, for example, incorporate complexity into the hierarchical structure, while maintaining low individual complexity (Espejo, 1992). While social systems naturally tend toward self-organization when struggling for cohesion in the face of turbulent (Bula & Espejo, 2012) environments, "complex adaptive systems" develop unity in the face of similar environmental situations (Espejo, 2004).

Systems can maximize their sensitivity to and ability to respond to environmental disturbances by disaggregating environmental complexity by generating recursions. When participants in an organization absorb environmental disturbances, it is possible to deduce a systemic identity (Espejo, 1996). Disturbances in the environment are understood as information by some cyberneticists, and as energy by others. Therefore, the more specialized the system becomes to deal with specific disturbances in the environment, the more differentiated its identity becomes. This is called the process of disaggregating complexity by incremental systemic recursions, or the "complexity unfolding method." (Espejo, 2004; Espejo, 1996) A graphical representation of the specialization and emergence of identity through the unfolding of complexity is presented in Figure 5.

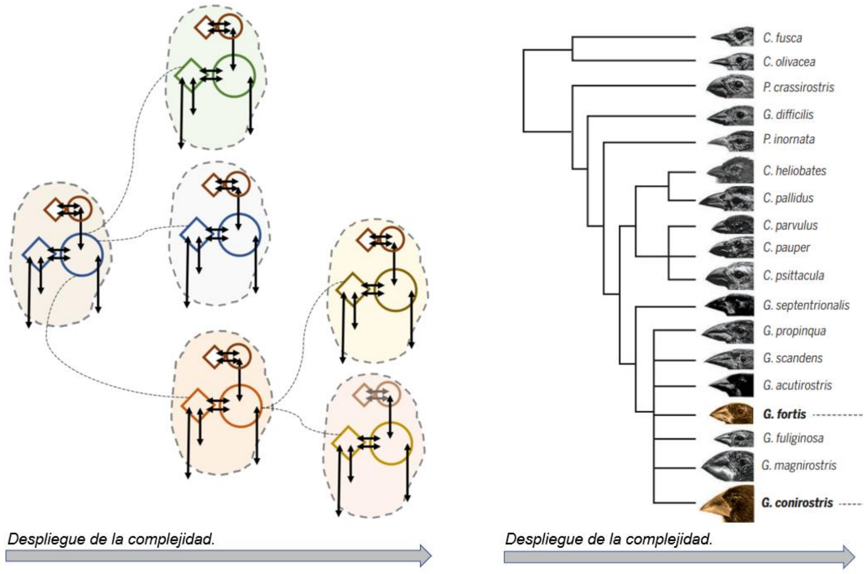


*Figure 5* – Deployment of complexity in viable systems and in the P inzones of the Galapagos Islands. Source: This research using the idea of unfolding the complexity (Espejo, 2004) and finches of Galapagos Islands in (Wagner, 2018).

Figure 5 shows an analogy between Galapagos finches peaks and the deployment of complexity in systems. Finch beaks have evolved by specializing in diets. While the deployment of complexity allows systems to specialize in absorbing specific environmental disturbances. In both cases, specialization becomes the identity of the systems, as anticipated by Espejo (1996).

# 6 The extended phenotype.

## 6.1 Extended phenotype analogy

Dawkins (1976) argues that natural selection acts on genes, not on individuals as Darwin (1885) thought. Therefore, organisms are only vehicles for gene replication. Darwin did not have any information on genetics but observed that the physical traits of parents favoured by selection are inherited by their children, and that these traits in turn give an advantage in survival to the individuals who possess them. Observable characteristics in organisms are a consequence of the genetic information that individuals carry.

The physical features observable as a result of the genotype of an organism are called the phenotype. Dawkins (1982) presented the revolutionary idea that the phenotype manifests itself not only in the observable characteristics of an organism, but also manifests itself in its natural behaviour. The beaver does not need to learn how to build a dam, the information needed to do so is included in his genetic material. By building a dam, the beaver increases its chances of survival, altering the environment and manipulating the surrounding landscape (Dawkins R. , 1982, pág. 59). Dawkins called these observable manifestations of an organism's genetics but not part of it, the extended phenotype. The long flat tail, and the large teeth of the beaver are a phenotypic expression of its genotype, as much as the dam that builds the animal. In turn, the environment selects individuals by their physical and behavioural characteristics. That is, selection acts on genes, mediating the visible manifestations of the genome, whether their phenotype, or their extended phenotype.

## 6.2 What selection acts on systems.

Beer (1989) claims to have indicated a limitation in the VSM with respect to the inheritance of acquired characteristics. We believe that, on the contrary, it is not a limitation of the model. It remains then to propose a way to connect the possibility of replication and inheritance in the evolutionary algorithm for social systems (VSM).

We propose here the adoption of the analogy of the genotype with the identity of the viable system, or System 5. As with living organisms, genes dictate not only the external form, but also the internal functions, the construction of the organism, and even the behaviour of the organism. In analogy with genetics in biological organisms, the identity of the system dictates, its behaviour, structure, and function, as much as the genotype does with biological organisms.

## 7 The dynamic relationship of systems and environment.

The beaver builds the dam to improve the chances of survival of its genes, but also alters the environment, producing changes in its environment, and affecting the interactions of other species with the environment. In viable systems the environment could be understood as a territory, overlapping geographies, political atmospheres, economies, coastal waters, etc (Beer, 1992). Systems exchange energy with their environments in their efforts to impose convenient conditions for viability, while the environment imposes back on systems variety (Beer, 1993, pág. 2). Beer considers that the variety of the environment is not defined (mapped) (Beer, 1993, pág. 20). Therefore, viable systems alter their environment to increase their viability, and in turn, are also shaped by it.

Although Beer understood an evolutionary relationship between systems and the environment, he does not elaborate in detail on these dynamics, on the other hand, (Adams, 1983) using the laws of thermodynamics and the concepts of Systems Far from Equilibrium (SFE), he identifies some behaviours of systems and their environments. It exemplifies the interactions between systems and environment, with the requirements and consumption of natural resources by human organizations located in a geographical territory. It narrates the way in which there is an energy exchange relationship between systems and their immediate environments, and between systems of different environments. Systems try to control their environment, humans do it through agriculture and industry (Adams R. , 2007, pág. 86) as much as other living beings do in their own way. This results in different degrees of pollution and resource depletion differentially in environments. The relationship of energy exchange with the environment drives evolution, and autopoiesis. (Adams, 1983; Tyrtania, 2008; Tyrtania, 2007; Ortiz, Delgado, Gomez, & Jullian-Montañez, 2013) Change in the environment in turn drives change in systems to adapt to it. The principle of entropy, understood as constant change, is the engine of evolution (Tyrtania, 2008). Systems, consequently, build their environment through the set of interactions available by their autopoietic organization (Vanderstraeten, 2001). This relationship is put by Tyrtania (2008) in terms of self-perception, saying that "Environmental systems evolve, through self-perception to adapt, and then model new territories and new self-perceptions" (Tyrtania, 2008).

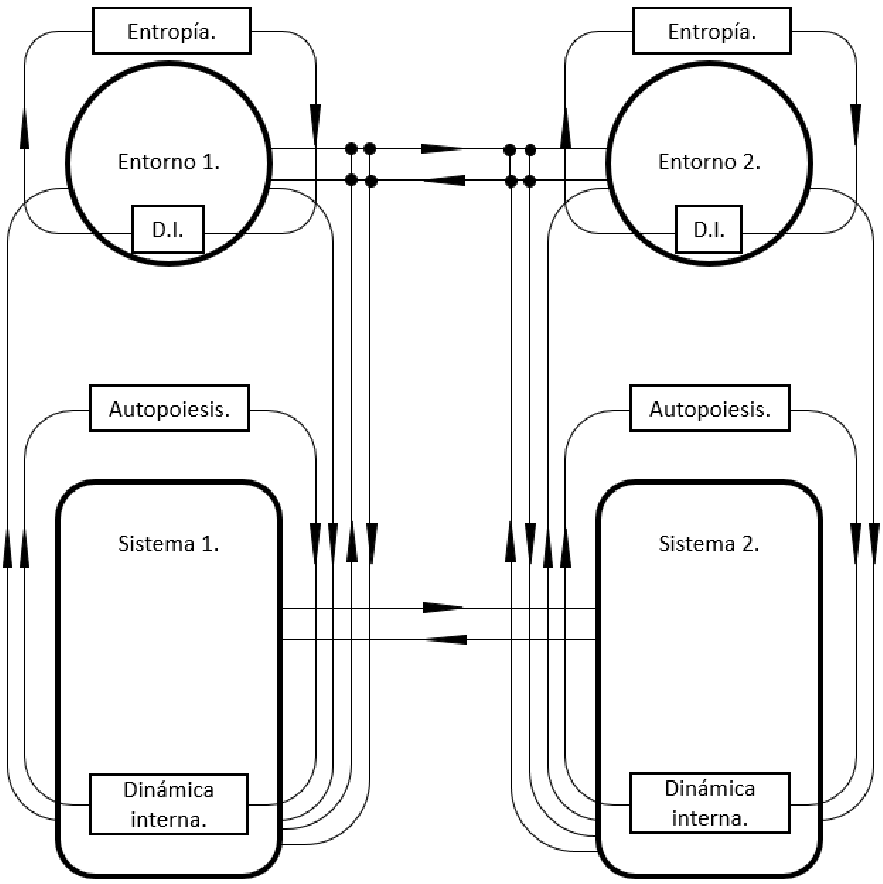


Figure 6. A cybernetic model of the relationship between systems and environment. *Source*: This research using Beer's notation (1975).

The model (Figure 6) shows two systems, 1 and 2 inserted into their environments. These systems have internal autopoietic dynamics, just as dynamics in the environment motivate entropy. Systems also interact with each other, consuming and delivering energy. Systems also consume energy in the form of resources and deliver it in the form of environmental degradation to their environment. In addition, they have a similar relationship with the immediate environments of other systems. These relationships lead to modelling the relationships of human networks with territories (Adams R. , 2007).

## 8 Adaptive Strategies in Viable Systems.

In this study we managed to identify three adaptive strategies in organizational systems.

We have discussed specialization as the most notable form of adaptation. Another, and more consistent with the identity of viable systems, is collaboration. Viable systems point to autonomy, self-organization, and collaboration Espinosa *et al.* (2007) . In the text the authors do not deepen the extension of the concept, however, we have identified that collaboration, cooperation, and mutualism, have not yet been discussed in depth in viable systems as strategies of adaptation to the environment.

Symbiosis, in its most elementary form, is understood as "coexistence". In nature, examples of symbiosis are prolific, showing two species benefiting from each other, in homeostatic relationships. A system benefits a second, by changing the environment in which it moves. Alternatively, both systems change their environments by helping each other survive. Symbiosis can take three forms: mutualism, commensurability, and parasitism according to Leonard (2007).

In coevolution, unlike symbiosis, each system can survive independently, adapting to the environment, using semi-autonomous strategies, constantly adjusting to the means or the general environment. This implies adapting to internal or external stimuli, seeking coherence with the environment (Dominici, Basile, & Palumbo, 2013). In coevolution, social systems influence themselves by showing consonance/resonance relationships that promote viability with each other through their interaction (Dominici & Palumbo, 2013).

## 9 Implications and new research.

This article has presented at least two important ideas that help close the knowledge gap linking environment-identity-feasibility.

The first relevant idea is that viable systems can be influenced by the environment in an evolutionary relationship. This has significant implications in the study of spontaneous organization and self-organization. This idea also makes it possible to link viable systems to theories of complex adaptive systems.

The second idea is that the identity of the system has direct implications for the viability of the system. It is important because, unlike living organisms, the identity of systems can change, making it easier to adapt to changes in the environment.

In this line, it is important to deepen what characteristics of identity have repercussions in the construction of the system, and in what form. This would allow more effective design of identity characteristics in search of the viability of the system. Advancing this issue would have direct implications for industry and entrepreneurship.

The next line of research suggested is on natural adaptation strategies. Knowing other evolutionary strategies would allow experimenting in types of organizational structures with a higher probability of viability. In particular collaboration, cooperation, and mutualism. An example of this is the recent publication of Osejo-Bucheli (2023; 2022), elaborated the relationship among Viable Systems and cooperative organizations.

Finally, in the field of symbiotic relations, and in coevolution, the limits of autopoietic processes remain to be discussed.

**Conflict of Interest Statement**

The author is a tenured professor at the University mentioned in the heading of the article; no funding has been received for this study; this article is not a product of any consultancy; no travel grants, speaking fees, writing fees, or other Honoria has been received; the article does not include any paid expert testimony; the subject of the article is not covered by any patent; the author is not a full or partial investor, proprietor, associate, of the sources this article is submitted to; no employment position is dependent of the publication of this article; nor the authors declare any conflict of interest.

References

Adams. (1983). *Energía y estructura, Fondo de Cultura Económica, México [traducción de Energy and Structure: A Theory of Social Power, [1975].* Austin: University of Texas Press.

Adams, R. (2007). *La red de la expansión humana.* . México : Centro de Investigaciones y Estudios Superiores en Antropología Social Universidad Iberoamericana.

Ashby, W. (1956). *Introduction to Cybernetics.* New York, NY.: Wiley. Retrieved from http://documents.irevues.inist.fr/bitstream/handle/2042/30159/XX_CNE-LIPSOR_000704.pdf?sequence=1

Ashby, W. (1958). Requisite variety and its implications for the control of complex systems. *Cybernetica 1:2*, 83-99. Retrieved from http://pcp.vub.ac.be/Books/AshbyReqVar.pdf

Bateson, G. (1991). *Pasos hacia una ecología de la mente* . Buenos Aires.: Planeta, Carlos Lohlé.

Beer, S. (1972). *Brain of the firm.* Devon: Wiley. Retrieved from https://scholar.google.com/scholar_url?url=https://agris.fao.org/agris-search/search.do%3FrecordID%3DUS201300488705&hl=es&sa=T&oi=gs

b&ct=res&cd=1&d=6459576379904445364&ei=F9tMYvf-DszBsQL6g4GYBA&scisig=AAGBfm1p06Jl7674LEHg1pKiEGsity6ZYQ

Beer, S. (1975). *Platform for change: A message from Stafford Beer*. New York: John Whiley.

Beer, S. (1979). *The heart of the Enterprise*. Chichester, UK: John Wiley & Sons.

Beer, S. (1989). *The viable system model*. Chicester: Wiley. Retrieved from https://www.kybernetik.ch/dwn/Viable_System_Model.pdf

Beer, S. (1992). Recursion zero: metamanagement. *Transactions of the Institute of Measurement and Control, 14(1)*, 51-56. doi:https://doi.org/10.1177/014233129201400108

Beer, S. (1993). *Designing freedom*. House of Anansi.

Beer, S. (1994). *Decision and Control: The meaning of operational. The meaning of operational research and management cybernetics*. London.: John Wiley & Sons. Retrieved from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fsyscoi.com%2Fmodel.report%2Fnkbtr.org%2Fdown%2FStafford_Beer_Decision_and_Control_The_Meaning_of_Operational_Research_and_Management_Cybernetics_1995.pdf&chunk=true

Bula, G., & Espejo, R. (2012). Governance and inclusive democracy. *Kybernetes Vol. 41 No. 3/4,*, 339-347. doi:https://doi.org/:10.1108/03684921211229442

Darwin, C. (1885). *The origin of species by means of natural selection: or, the preservation of favoured races in the struggle for life*. Devon: J. Murray.

Dawkins, R. (1976). *The selfish gene*. Oxford: Oxford University Press.

Dawkins, R. (1982). *The extended phenotype: The long reach of the gene*. Oxford: Oxford University Press.

Dawkins, R. (2010). *The greatest show on earth: the evidence for evolution*. London.: Free Press.

Dennett, D. (2009). The evolution of culture. In S. Dick, & M. (. Lupisella, *Cosmos & Culture: Cultural Evolution in a Cosmic Context*. (pp. 125-143). National Aeronautics and Space Administration, Office of External Relations, History Division.

Dominici, G., & Palumbo, F. (2013). Decoding the Japanese lean production system according to a viable systems perspective. *Systemic Practice and Action Research, 26(2)*, 153-171. doi:https://doi.org/10.1007/s11213-012-9242-z

Dominici, G., Basile, G., & Palumbo, F. (2013). Viable systems approach and consumer culture theory: A conceptual framework. *Journal of Organisational Transformation & Social Change, 10*(3), 262-285.

Espejo, R. (1989). Method to Study Organizations. In R. Espejo, & R. (. Harnden, *The Viable System Model.* Chichester: Wiley.

Espejo, R. (1989). The Viable System Model Revisited. In R. a. Espejo, *The Viable System Model: Interpretations and applications of Stafford Beer's VSM.* Chichester.: Wiley.

Espejo, R. (1992). Management of complexity in problem solving. *Transactions of the Institute of Measurement and Control 1992 14: 8*, 1-10. doi:DOI: 10.1177/014233129201400103

Espejo, R. (1996). Requirements for effective participation in self-constructed organiztions. *European Management Journal Vol. I4, No. 4,*, 414-422. doi:https://doi.org/10.1016/0263-2373(96)00029-1

Espejo, R. (2004). The footprint of complexity: the embodiment of social systems. *Kybernetes, Vol. 33 No. 3/4*, 671-700. doi:https://doi.org/10.1108/03684920410523643

Espejo, R. (2013). Organisational cybernetics as a systemic paradigm: lessons for the past - progress for the future. *Business Systems Review (ISSN 2280-3866), Special Issue – Selected Papers of the 1st Business Systems Laboratory Internationational Symsposium, Vol. 2 No. 2*, 1-9. Retrieved from https://ssrn.com/abstract=2242459

Espinosa, A., Harnden, R., & Walker, J. (2007). Beyond hierarchy: a complexity management perspective. *Kybernetes.Vol. 36 No. 3/4*, 333-347. doi:https://doi.org/: 10.1108/03684920710746995

Leonard, A. (2007). Symbiosis and the viable system model . *Kybernetes, Vol. 36 Iss 5/6* , 571 -582. doi:http://dx.doi.org/10.1108/03684920710749677

Maturana, H., & Varela, F. (1997 [1973]). *De máquinas y seres vivos. Autopoiesis, la organización de lo vivo.* Santiago de Chile: Editorial Universitaria.

Ortiz, P., Delgado, A., Gomez, F., & Jullian-Montañez, A. (2013). Los lenguajes de la complejidad. In P. Ortiz, A. Delgado, & F. Gomez, *Sistemas alejados del equilibrio: un lenguaje para el diálogo transdisciplinario.* (p. 137). Tlaxcala: Clave.

Osejo-Bucheli, C. (2022). Theory Evaluation and Formulation: A Reply to Ludic Theory through A.N.Whitehead´s Aesthetic Experience. *Philosophy of Management 21*, 415–440. doi:https://doi.org/10.1007/s40926-022-00194-4

Osejo-Bucheli, C. (2023). Contributions to anarchist-cybernetics, identifying committee directorates with Errico Malatesta´s theory: Content analysis using dynamic causal diagrams and viable system modelling. *Kybernetes (14)1*. doi:10.1108/K-07-2022-0944

Tyrtania, L. (2007). Termodinámica de la supervivencia para la sociedad humana. In R. Adams, *La red de la expansión humana*. . México: CIESAS.

Tyrtania, L. (2008). La indeterminación entrópica: Notas sobre disipación de energía, evolución y complejidad. *Desacatos, (28)*, 41-68. Retrieved from http://www.redalyc.org/articulo.oa?id=13902805

Vahidi, A., Aliahmadi, A., & Teimoury, E. (2018). Researches status and trends of management cybernetics and viable system model. *Kybernetes,*, 1-33. doi:https://doi.org/10.1108/K-11-2017-0433

Vanderstraeten, R. (2001). Observing systems: A cybernetic perspective on system/environment relations. *Journal for the Theory of Social Behaviour, 31(3)*, 297-311. Retrieved from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://cepa.info/fulltexts/1133.pdf

Wagner, C. (2018). Improbable Big Birds. Darwin´s finches prove a mechanism for the rapid formation of new species. *Science*, 157-159. doi:https://doi.org/10.1126/science.aar4796

Walker, J. (1991). *Viable Systems Model, a guide for co-operatives and federations*. ICOM, CRU, CAG and Jon Walker. Retrieved from https://vsmg.lrc.org.uk/screen.php?page=home