

ARTICLE

HOW CYBERNETICS EXPLAINS BEHAVIOURAL TENSEGRITY AND ITS ADVANTAGES FOR SOCIETY

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Our regular contributor Dr Shann Turnbull builds on the engineering principle of tensegrity, in which conflicting behaviour of different materials introduce systemic self-correction to disturbances. Distributed decision-making, described as polycentric governance, is required to systemically generate conflicting checks and balances.

INTRODUCTION

The cybernetic 'law of requisite variety'¹ explains why natural systems, biota and self-governing social organisations possess paradoxical opposing but complementary, dual behaviours described as 'tensegrity'.² These dual opposing but interdependent, Yin~Yang-like behaviours create various checks and balances required for self-regulation and self-governance.³ Crucially, tensegrity drives evolution by continuously generating organisational adaptations required to survive ever-changing and so unknown environmental conditions.⁴

This article explains how the contrary behaviour of tensegrity undermines the most influential theories of firms and agency theory. Also explained is how in modern societies, tensegrity in individuals is inhibited, denied and punished in the centralised command and control hierarchies that dominate the public, private and nonprofit sectors. This may explain why tensegrity and its advantages for firms and global governance have been overlooked.

Even Ostrom,⁵ who identified design principles for self-governance in her Nobel Prize acceptance

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1. Ashby, 1956, p. 206
 2. Turnbull and Guthrie, 2019, p. 54
 3. Ingber et al., 2014
 4. Ingber, 2000, 2008
 5. Ostrom, 2009, p. 422

speech, did not identify the need for opposing behaviour. This is because opposing behaviour already existed in her case studies involving competition for control of common pool resources (CPRs) that could otherwise create a 'tragedy of the commons'.⁶

Ostrom's⁷ case studies were mainly concerned with unincorporated CPRs like hunting, gathering, fishing and water resources. Property rights were considered by Ostrom but in a way that allowed them to be ignored in her design principles. Nevertheless, property rights cannot be ignored with incorporated CPRs. The endowments of citizens with CPR property rights to create locally owned and controlled bioregional self-governing eternal circular economies are crucial in reformatting Ostrom design principles.⁸

Business corporations introduce competitive claims to corporate resources not just between shareholders and other stakeholders but between different stakeholder constituencies. For example, suppliers of goods and services have incentives to increase prices, while customers possess opposing incentives to seek reduced prices.

Suppose corporate resources are to become a CPR providing benefits for all stakeholders, as proposed by the US Business Round Table. In that case, each stakeholder constituency needs to establish its own independently elected representative bodies to introduce what Ostrom describes as 'polycentric' governance.

Polycentric governance introduces tensegrity from the *tensions* between different stakeholder interests, together with the *integrity* of divided

power to negotiate win-win solutions to distribute benefits to all stakeholders. This is consistent with Fuller⁹ coining the word 'tensegrity' by combining the words 'tension' and 'integrity'.

Despite its potential, the phenomenon of tensegrity has been overlooked by social scientists. The author pioneered its introduction to social analysis in his PhD dissertation when he initially described it as 'social tensegrity'.¹⁰

Social scientists may have neglected tensegrity because they have: (a) described the phenomenon with different words like 'paradox'¹¹ which is considered dysfunctional and something neither positive nor systemic; (b) discounted the ancient Yin~Yang terminology as being irrelevant to modern society and organisations, not recognising that the phenomena is hard-wired into all humans and other biota;¹² (c) focused their research on publicly traded firms that inhibit, deny and punish contrary individual behaviour for denying tensegrity emerging and being identified;¹³ (d) not appreciated that tensegrity facilitates behavioural adaptation in individuals and organisations; (e) not recognised that tensegrity is the driver of evolution throughout the universe¹⁴ to suggest social organisations could also adopt it.

Biota cannot survive without the ability to become self-governing and reproduce in unknown dynamic complex environments. Understanding how tensegrity continuously generates and reproduces comprehensive adaptations is vital for understanding the processes of creating sustainable physical, biological or social wellbeing. This understanding is required to ensure that the concept of tensegrity is embedded into any local and global system of governance.

6. Hardin, 1968

7. Ibid.

8. Turnbull, 2022a, p. 97

9. Fuller, 1961

10. Turnbull, 2000b, pp. 8, 69, 84, 134, 135, Turnbull, 2014b, pp. 11, 85, 103, 172, 173, 174, 179

11. Smith and Lewis, 2011

12. Ingber et al., 2014

13. Turnbull, and Poelina, 2022, p. 16

14. Suggested by Bohm, 1980; Ingber, 1998, p. 39

This article also explains how centralised command and control hierarchies that dominate modern society inhibit, deny and punish contrary behaviour. This has denied insights into how to introduce self-governance to avoid tragedies of the commons without 'markets or State'.¹⁵ Self-governance requires decentralisation of power to allow bottom-up and outside-in decision-making influences, as well as top-down guidance. Tensegrity is a defining feature of a polycentric type of governance that creates a 'holonic' architecture described by Turnbull and Guthrie.¹⁶ It allows complex global problems to become locally simplified with various supplementary controllers to 'amplify regulation'.¹⁷

The following section outlines the significance of introducing tensegrity to organisational analysis and how its emergence in firms is dependent on them possessing distributed decision-making. I then explain how tensegrity is denied in economic and financial analysis. Systemic operating problems arising in hierarchical organisations are discussed in the following section. Alternatives to hierarchies and the knowledge gap in teaching self-governance are then reviewed, followed by a 'call to action' in promoting the transformation of the theory and practice of corporations for the benefits for all stakeholders. Concluding remarks raise the need to educate governance architects and research the role of tensegrity in the universe.

THE SIGNIFICANCE OF TENSEGRITY IN A SOCIAL CONTEXT

The need to understand the concept of tensegrity arises because it explains how to design and establish self-governing organisations that can reduce the role, size and cost of government, as well as reliance

on markets that have failed. Lord Stern advised the UK government in 2006 that climate change was created by the 'the biggest market failure the world has ever seen'.¹⁸ This failure continues, aggravating existential risks to humanity as neither Stern nor anyone else has proposed stopping market failure except your author.¹⁹

Another threat to humanity that makes self-governance and, therefore, tensegrity arises from the need to counter the degradation of the atmosphere, oceans, sources of fresh water, soils and biodiversity locally. These problems create another reason for introducing local self-governing bioregional organisations to engage locally with citizens to take corrective action on a collective self-determined democratic basis. No such facility exists on either a global or national basis. A crucial need for such local democratic institutions is to manage the population density in each bioregion in a way that is consistent with establishing eternal circular economies.²⁰

Humanity is exposed at the global level, what has been described at the local level as 'the tragedy of the commons'.²¹ Ostrom²² identified how this tragedy could be avoided with 'polycentric self-governance'. Introducing tensegrity would provide a basis to convert polycentric governance into an ecological form of governance ubiquitously found in nature. Ostrom identified how polycentric self-governance required neither markets nor states, which is consistent with them not being used by nature. Two features found in biota but not included in Ostrom's design principles were limits on size and age.

Biologist Ingber²³ described tensegrity as 'the architecture of life'. He explained how 'tensegrity structures offer a maximum strength for a given

15. Ostrom 2009, Turnbull, 1994

16. Turnbull, and Guthrie, 2019

17. Ashby, 1956, p. 265

18. Stern, 2007, p. xviii

19. Turnbull, 2022b

20. Turnbull, 2021b

21. Hardin, 1968

22. Ostrom, 2009

23. Ingber, 1998, p. 30

amount of building material'. One way of explaining the success of polycentric governance in social organisations is that it allows the engagement of the maximum number of individuals while minimising data overload of the individuals involved in decision-making, control and communications. Here it is consistent with Wiener's²⁴ concept of cybernetics as the science 'of control and communication in the animal and the machine'.

The application of tensegrity from physical and biological structures to social relationships

The application of tensegrity from physical and biological structures to social relationships was achieved by using bytes as the unit of analysis.²⁵ Shannon²⁶ and Ashby,²⁷ who founded the science of cybernetics, referred to 'bits' as their unit of analysis. Eight bits is described as a 'byte', a term used to define the storage and processing capacity of electronic devices. For this reason, the word byte is preferred to the word 'bit' that has an alternative connotation.

At the end of the last century, research scientists²⁸ at the British Telecom organisation identified humans' physiological limits to receiving or transmitting bytes. Other scientists²⁹ identified the ability of our brains and nervous systems to process and store bytes. These limits provide governance architects with fundamental criteria for designing reliable and resilient organisations using elementary cybernetics' insights.

In applying the law of requisite variety, Ashby³⁰ pointed out that 'The gene pattern, as a store of channel of variety, has limited capacity. Survival goes especially to those species use the capacity efficiently'.³¹ This indicates the need for living things to minimise the materials and energy required to transact bytes/data for living things to be created, survive birth, thrive and reproduce in an unknowable dynamic complex environment.

The ability of gene patterns to guide behaviour can arise from direct programming and the more efficient amplification process. Ashby explains how 'amplifying regulation'³² is only possible indirectly through supplementary sources of variety provided by the environment.³³ The dual paradoxical nature of tensegrity generates the requisite variety required for 'regulating the very large system'.³⁴ This leads to our first hypothesis.

Hypothesis 1. Tensegrity creates a requisite variety of instinctive and learned behaviours for living things to survive their creation and reproduce in dynamic unknowable complex environments while minimising the material and energy required in their DNA.

The human brain vividly illustrates the physical demands of data processing. While the weight of matter in the brain is less than 2% of the total body weight, the amount of energy is ten times greater, 20% of the total used by the body even at rest.³⁵ The energy used by different brain parts varies according to how vital the data channel is for survival.³⁶

24. Wiener, 1948

25. Turnbull, 2000, p. 1, Turnbull 2014b, p. 1

26. Shannon, 1948, p.1

27. Ashby, 1956, from p. 126 onwards

28. Cochrane, 2000

29. Kurzweil, 1999

30. Ashby, 1956, p. 270

31. Ibid., p. 244

32. Ibid p. 265

33. Ibid.

34. Ibid., p. 244

35. <https://hypertextbook.com/facts/2001/JacquelineLing.shtml>

36. <https://www.brainfacts.org/brain-anatomy-and-function/anatomy/2019/how-much-energy-does-the-brain-use-020119>

Tensegrity in organisations arises from distributed decision making

The architecture of our brains' communication and control channels also illustrates distributed decision-making that is representative of polycentric governance. According to neurologist Kelso,³⁷ different brain areas become responsible for making decisions. Kurzweil³⁸ reports that: 'There is no Chief Executive Officer neuron'. Different parts of the brain compete with others for dominance according to internal needs and drives and external risks and opportunities for

survival. Such distributed (polycentric) decision-making provides a way to decompose decision-making to reduce the data processing material and energy required at any location while also allowing parallel decision-making.

An illustration of how organisational decision-making can be decomposed and so simplified is provided in Figure 1. It shows how the eleven identified activities of directors of an 'Anglo' unitary board, marked with an X, are distributed to five differently constituted 'Control centers' of a 'Mondragón compound board'.

FIGURE 1: MONDRAGÓN COMPOUND BOARD COMPARED WITH UNITARY BOARD³⁹

BOARD TYPE →	MONDRAGÓN COMPOUND BOARD					ANGLO
Control centres ^a	Watchdog Council	Supervisory Board	Management Board	Social Council	Many Work Units of:	Unitary Board
Members	3	5-8	4-6	~5-25	~10-20	~4-12
Function ^b	Governance processes	Appoint Management Board	Organise operations	Worker welfare	Production, Elect Social Council	Manage
Activities	Efficacy and integrity of processes	Integrate strategic stakeholders	Efficient allocation of resources	Establish working conditions	Job organisation and evaluation	Direct and control
Internal ^b	X		X	X	X	XXXX
External ^b	X	X				XX
Short term ^b	X		X		X	XXX
Long term ^b		X		X		XX

Degree of decomposition of information processing labour indicated by allocations of 'X'

a Omits the General Assembly, which elects Watchdog Council and Supervisory board;

b Descriptions follows typology of R. I. Tricker, Corporate Governance: Principles, Policies and Practices

37. Kelso et al., 2013

38. Kurzweil, 1999, p. 84

39. Turnbull and Guthrie 2019, p. 67

The separation of powers introducing checks and balances in decision-making is similar to the way our brains are designed to exhibit the contrary-complementary behaviour of tensegrity. Behaviour that may be inhibited or dysfunctional from 'group think' can emerge in an organisation with a single board.

TENSEGRITY IS DENIED IN ECONOMIC AND FINANCIAL ANALYSIS

Three years before Jensen and Meckling⁴⁰ published their agency theory of the firm, Wearing, a professor of psychology, identified in 1973 how the model of human behaviour used by economists and finance scholars was inconsistent with reality as set out in his Table 1: Differences between 'Economic People' and 'Real People'.⁴¹

TABLE 1: DIFFERENCES BETWEEN 'ECONOMIC PEOPLE' AND 'REAL PEOPLE' (WEARING 1973)

	ECONOMIC PEOPLE	REAL PEOPLE
1	Unlimited appetite	Appetite determined and limited by the necessity of maintaining the organism in a state of dynamic equilibrium.
2	Completely informed	Reduces, condenses, summarises (and thus necessarily loses) information. In addition, an 'imperfect' communications network in the environment also restricts and attenuates the flow of information.
3	Consistently orders his/her preferences between outcomes over time	Does not consistently order his/her preferences (i.e., changes his/her mind over time, may prefer A to B, B to C but C to A).
4	Maximises something (usually one thing)	Attempts to optimise concerning many criteria (needs).
5	Competitive	Sometimes competitive, sometimes collaborative, and usually both.
6	Requires a value system only in order to provide a criterion against which to maximise (e.g., profit, utility, prestige and power)	Requires a value system to provide a framework for the ordering of needs, the selection of information and the weighing of multiple decision criteria.
7	Not explicitly related to the world as an element in interactive system and remains unchanged, as a result of any interaction	Stands in an interactive cybernetic relationship to his/her community and environment and is changed, as a result, of any interaction.
8	No significant differences between individuals	Differences between individuals are significant and important.
9	No limits on information processing capacity, so is unaffected by differences in rates of change	Limited information processing capacity so prefers slow rates of change, (i.e., nearly stable systems).
10	Needs are simple and few	Needs are simple and many.

40. Jensen and Meckling, 1976

41. Wearing, 1973

As discussed below, agency theory was based on a model of human behaviour that does not match reality. Perhaps, to respond to critiques of agency theory over the following 18 years, Jensen and Meckling published in 1994 'The Nature of Man'. They concluded 'that the explanatory power of REMM, the resourceful, evaluative, maximising model of human behaviour, dominates that of all the other models'.⁴²

The REMM model supports agency theory as it assumes 'maximising', which is consistent with the 'unlimited appetite' in the first row of 'Economic People' of Table 1. REMM is also consistent with 'Economic People' in row 3 in that 'Individual preferences are transitive – that is, if A is preferred to B, and B is preferred to C, then A is preferred to C'.⁴³ But as Wearing points out, individuals can change their minds over time to prefer A to B, B to C but C to A! This is an acceptance that, in reality, individuals can take opposing positions to exhibit the dynamics of tensegrity.

Wearing also recognised the dynamics of human nature by introducing cybernetics in row seven stating that 'Real People' 'stand in an interactive cybernetic relationship to his/her community and environment and is changed as a result of any interaction'. The dynamic view was supported by Kelso and Engstrøm⁴⁴ who reported: 'Experiments show that the human brain is capable of displaying two apparently contradictory, mutually exclusive behaviours at the same time'.

Kelso and Engstrøm introduced the tilde '~' notation, adopted in this article, to indicate the paradoxical dual contrary~complementary interdependent relationships present in our brains and many other contexts, including evolution⁴⁵ and the universe.⁴⁶

The REMM model is static like the other models considered by Jensen and Meckling. In addition, in row eight of Table 1, 'Real People' are characterised by 'Differences between individuals are significant and important'. This means the assumptions of agency theory, which are based on the REMM model, cannot apply to everyone, and when they do, they cannot be relevant for most of the time in a dynamic world that recognises the existence of tensegrity.

Recognising tensegrity undermines Coase and Williamson's assumption that firms involve a 'master and servant' or 'employer and employee'⁴⁷ authority system as found in command and control hierarchies. Williamson noted that he was not concerned with worker cooperatives like Mondragon.⁴⁸

As command and control hierarchies dominate public, private, non-profit and government organisations, there has been no widely accepted theory of all other types of firms and social organisations. Examples are partnerships, cooperatives, mutuals, incorporated joint ventures, associations, and those that mimic the self-governing processes in traditional Indigenous⁴⁹ societies, nature and other species.

Extending the theory of firms to any social organisation of any species

The Coase explanation of why firms exist can be explained in terms of market failure. Markets did not exist to supply complex components of novel goods and services; if they could evolve, they were too costly. The cost of using markets to create products could be greater than the cost of employing workers. It was quicker, simpler and more certain to employ a servant to make them

42. Jensen and Meckling, 1994, p. 33

43. Ibid, p. 4

44. Kelso and Engstrøm, 2006, p.120

45. Smuts, 1926, p. 59; Ingber, 1998, p. 39; Mathews, 1996, p. 50; Hock, 1999

46. Bohm, 1980, Ingber, p. 39

47. Coase, 1937, p. 13

48. Williamson, 1975, p. 265

49. Turnbull and Poelina, 2022, p. 29-30

than to buy them. This led Williamson to develop transaction cost economics (TCE) as a theoretical basis for investigating firms organised as various types of command and control hierarchies.

The idea of using 'transactions' as a 'numaire of analysis' was suggested 14 years before the science of cybernetics was established in 1948.⁵⁰ Costs cannot be defined in terms of any one or more tangible things, and the difficulty in identifying and/or defining all transactions compounds the lack of rigour of TCE.

TCE is subsumed and extended by transaction byte analysis (TBA) with increased rigour. Bytes are perturbations in energy and material that makes a difference that can be objectively metered. It establishes 'the science of governance'⁵¹ and 'the science of corporate governance'⁵². TBA allows any social organisation to be analysed of any species, as indicated in Table 2, 'Comparison of TCE and TBA boundaries'.⁵³

TABLE 2: COMPARISON OF TCE AND TBA BOUNDARIES⁵⁴

FRAMEWORK OF ANALYSIS →	TRANSACTION COST ECONOMICS (TCE) (Coase/Williamson)	TRANSACTION BYTE ANALYSIS (TBA) (Developed by the Author)
1 Type of social institution	For-profit firms, not labor managed	Any social organisation of any specie including any type of firm
2 Subject of analysis	Transactions and their costs	Biota/people and the quanta (bytes) of data they can receive, process, store, retrieve, use and/or transmit
3 Relationship of biota (people)	Master/servant or competitive	Any e.g., family, cooperative, competitive, associative, etc.
4 Biota behaviour	Self-interest	Any e.g., altruistic, self-interest, etc.
5 Objectives	Economising costs	Anything (for firms, economising the transaction of bytes by people while compensating for errors with redundancy)
6 Basis for objective	Normative	Physiological and neurological limits in transacting bytes
7 Modes of governance	Markets, hierarchies, or hybrids of both	Any combination of clans/communities, associations, hierarchies and/or markets
8 Communication and control through:	Markets and hierarchies	Senses, semiotics, language, geometry, positioning of biota and their numbers
9 Firms exist because:	Markets fail to provide cost reducing components	Two or more people can reduce 'bounded rationality' and allow specialisation in abilities and/or knowledge and/or wisdom

50. Commons, 1934, pp. 4-8

51. Turnbull, 2008

52. Turnbull, 2002

53. Turnbull, 2000b, updated version of Table 7.1, p. 255. Turnbull, 2014b, updated version of Table 7.1, p. 336

54. A comparison of TBA and other theories of the firm are presented in Table 7.3 of Turnbull, 2000b, pp. 266-7 and Turnbull, 2014b, pp. 349-50

TBA provides a methodology for grounding the analysis of decision making, communication and control within and between any life forms, including plants or physical processes in the universe.⁵⁵ Plants draw attention to how the growth architecture can be governed by changes in the shape and configurations of their parts. As Ingber⁵⁶ pointed out, stresses observed by one part of a structure that possesses tensegrity, like a cell, are communicated throughout the entire structure to change its shape, changing its function for the system in which it operates. TBA also provides a basis to apply the law of requisite variety to identify the inherent limitations of hierarchical organisations, as is next considered.

OPERATING PROBLEMS OF HIERARCHICAL ORGANISATIONS

Four systemic dysfunctional physical problems can be identified in simple centralised command and control hierarchies.

1. Data overload by centralised decision makers without error-correction mechanisms, leading to delegation and the implementation of decisions to subordinate levels to form a hierarchy and additional problems outlined below.
2. Data losses, biases and distortions from subordinate level feedback without error-correction processes.
3. Discretionary interpretation by subordinates in determining the details of how to implement superior-level communications without error-correction processes.
4. No systemic external feedback channels to detect mismanagement, misconduct and malfeasance independently of those responsible.

In addition, at least five behaviour problems can be identified arising from the power relationships in simple centralised command and control hierarchies. These are as follows:

1. Centralised decision-making introduces absolute power for decision-making individuals to identify and manage their conflicts of interest to corrupt themselves, their organisation, its stakeholders and society.⁵⁷
2. Blind obedience to authority by subordinates creating 'group think'⁵⁸ to deny adequate variety of reliable feedback.
3. Excess exploitation of subordinates to alienate them as loyal cooperators and as reliable communication and/or control agents.
4. Behavioural tensegrity by employees and/or agents is suppressed, inhibited, prohibited and/or punished to frustrate discovery of superior operating processes.
5. Behavioural tensegrity by the organisation is denied, frustrating identifying novel ways to adjust to complex dynamic environments.

Using authority as described above creates toxic⁵⁹ relationships to aggravate the systemic dysfunctional physical data processing described.

The above observations suggest two additional hypotheses:

Hypothesis 2: Tensegrity is frustrated, denied and excluded in centralised command and controlled hierarchies that become systemically subjected to 'group think' to reduce the organisation's ability to self-regulate, self-manage and self-govern like living things.

55. Suggested by Bohm, 1980, and Ingber, 1998, p. 39

56. Ingber, 1998, p. 38

57. Acton and Fears, 1985

58. Fink, 2018

59. Carucci, 2018

Hypothesis 3: Tensegrity is required in social organisations to provide a requisite variety of cross-checking decision making, communication and control facilities to reliably and comprehensively identify and control internal needs and external risks, threats and opportunities to its existence.

Here the dual nature of holons becomes relevant. In discussing holons, as both a 'part' and a 'whole', Mathews introduced the work of quantum physicist Bohm.⁶⁰ Mathews stated that 'like Smuts before him, Bohm departed from the conventional view that sees systems composed of the behaviours of its parts (e.g., electronic phenomena as being explained by the activities of electrons) was organised by the whole'.⁶¹

If cybernetics can explain why tensegrity is ubiquitous in biology, then Mathews' observations suggest that the role of tensegrity could be extended into the physical world. This leads to three speculative hypotheses below that were included in another article with a 'Table 2: Identifying dual behaviour of humans/biota/holons/holarchy and the universe'.⁶²

Hypothesis 4. For evolution to be maintained, new emerging entities or phenomena need to reproduce the dual paradoxical features of tensegrity to generate a requisite variety of novel conditions to arise in different contexts for the process of evolution to continue.

Hypothesis 5. Evolution could not have commenced unless tensegrity emerged with time, with both becoming embedded in all matter and energy.

Hypothesis 6. The disappearance of time with its paradoxical dual complementary phenomenon of tensegrity is suggested by presence of dark matter and energy.

The phenomenon of tensegrity in individuals and organisations also seems to be a neglected or hidden topic. One explanation could be that management research is dominated by studies of publicly traded firms where hierarchical power structures inhibit their emergence from being detected.

Is behavioural tensegrity hidden and neglected?

The study of tensegrity could also be concealed because of the use of related but different words. Schumacher⁶³ introduced a more appropriate existing word, 'antinomy', in his chapter 'Towards a theory of large-scale organisation' when he referred to the antinomy of order and freedom. Management scholars Smith and Lewis⁶⁴ reviewed related literature on paradoxes that trace their origins to 'Yin~Yang'. Hock,⁶⁵ the founding CEO of the polycentric governed VISA card firm, coined the word 'Chaord' to describe the presence of tensegrity by combing the words 'Chaos' and 'Order'.

Hock describes the governance architecture found in nature that recognises the presence of tensegrity without using the word. Hock⁶⁶ described a 'Chaord' in two different ways:

- I. Any self-organising, self-governing, adaptive, nonlinear, complex organism, organisation, community, or system, whether physical, biological, or social, the behaviour of which harmoniously combines characteristics of both chaos and order.

60. Bohm, 1980

61. Mathews, 1996, p. 37

62. Turnbull and Poelina, 2022, p. 25

63. Schumacher, 1975, p. 209

64. Smith and Lewis, 2011

65. Hock 1999, Inside front cover

66. Ibid, p. 30

2. An entity where behaviour exhibits observable patterns and probabilities not governed by the rules that govern or explain its constituent parts.

Hock⁶⁷ described 'chaordic' in three ways:

1. The behaviour of any organism, organisation, or system that harmoniously blends characteristics of order and chaos.
2. Patterned in a way dominated by neither chaos nor order.
3. Characteristic of the fundamental organising principles of evolution and nature.

Hock⁶⁸ also identified the inherent problems of hierarchical organisations as described above by stating:

Industrial Age, hierarchical command and control pyramids of power, whether political, social, educational, or commercial, were aberrations of the Industrial Age, antithetical to the human spirit, destructive of the biosphere and structurally contrary to the whole history and methods of biological evolution. They were not only archaic and increasingly irrelevant; there was a public menace.

There are various alternatives to hierarchical organisation forms. These are considered in the following section.

ALTERNATIVES TO HIERARCHIES

There are various alternative organisational design concepts to consider, like the 'viable systems model',⁶⁹ 'syntegrity',⁷⁰ 'sociocracy',⁷¹ 'holacracy',⁷²

'heterarchy',⁷³ 'polycentric governance'⁷⁴ and 'holarchy'⁷⁵. Each describes some form of decentralisation with various degrees of bottom-up decision making. They all can provide valuable alternatives and adjuncts to simple hierarchies. Organisations incorporated as 'for benefit' or 'B corporations' remain a hierarchy. They do not remove the toxic problems identified above.

Syntegrity operates at the smallest scale, typically up to 30 individuals.⁷⁶ VSM involves a division of a firm with sociocracy used mainly for managing non-profit community associations. A holarchy and a heterarchy typically involve a whole organisation. Polycentric governance and holarchies may involve many organisations forming network relationships. A heterarchy⁷⁷ is itself a network of decision-making centres like a holarchy. What makes them different is that a holarchy is made up of holons by definition. A defining feature of a holon is that it possesses tensegrity to create another point of differentiation between a heterarchy, a holacracy and a holarchy. This also explains why hierarchies and a holacracy are different from a holarchy.

Holacracy is a business name used by a company incorporated as HolacracyOne in Pennsylvania⁷⁸ in August 2006 with limited liability. The corporation provides consulting services to introduce a distributed network management form registered in its bylaws⁷⁹. It has a single board of directors representing its shareholders. Its bylaws introduce distributed decision-making with its staff who may also be its shareholders, but neither are its shareholders or other stakeholders, like its clients,

67. Ibid.

68. Hock, 1995, pp. 7-8

69. Beer, 1995

70. Beer, 1994; Espinosa, and Harnden, 2007

71. Rau, 2021

72. Robertson, 2015; Kettering, 2020; Holacracy, 2021

73. McCulloch, 1945

74. Ostrom, 2009

75. Mathews, 1996

76. Espinosa, and Harnden, 2007

77. IMPA, 2018

78. https://opencorporates.com/companies/us_pa/3665532

79. Holacracy, 2021

recognised in the bylaws. The bylaws are sufficiently flexible to allow idiosyncratic outcomes in its own success and that of its clients.

Bernstein et al.⁸⁰ and Velinov and Densisov⁸¹ provide evidence that holacracy could provide useful auxiliary guidelines for the Ostrom Principles. Bodie⁸² reports that Delaware Law would allow elements of holacracy and sociocracy to be recognised in corporate constitutions. This is no surprise. It reveals that scholars have neglected to note how the law in many jurisdictions around the world allows corporate constitutions and bylaws to introduce distributed decision making as reported by many researchers.⁸³

Ostrom uses polycentric governance to describe when a CPR is managed by competing interests. However, it could also be used to describe heterarchical organisations that lack tensegrity. Such organisations could also be described as possessing 'network governance'⁸⁴ with and/or without competing interests.

Network governance introduces comprehensive engagement with influential competing stakeholder interests to provide a basis for developing an ecological form of governance found in living systems with the capacity to become self-governing. However, there is a global gap in knowledge and practice in evaluating, designing and transforming organisations to introduce self-governance. This gap exists with social scientists, not engineers and natural scientists, who already know how to design, build and operate self-governing automobiles and self-governing space exploration devices.

Filling the knowledge gap

Filling the knowledge gap requires integrating different contributions of theorists using different words to describe common phenomena. Mathews⁸⁵ reviews several pieces of literature in this regard. He identified how Smuts⁸⁶ introduced the concept of 'holism' in 1926. This is a feature that Simon⁸⁷ described and developed in 1962 by referring to 'sub-systems', 'able to maintain a separate existence', 'nearly decomposable systems in which the interactions among sub-systems are weak, but not negligible'. Simon was describing what is now conceptualized as a 'holon', a word introduced by Koestler⁸⁸ five years later. Koestler described a network of holons as a 'holarchy'. As described above, Hock coined his own word 'Chaord' to describe a holon.

While Mathews⁸⁹ does not use the word tensegrity, he identifies their dual contrary~complementary characteristics when describing the behaviour of holons as possessing: 'Centralisation/decentralisation'; 'Bottom-up/top-down'; 'Autonomous/integrated'; 'Order/ambiguity'. He concludes that this behaviour is a defining feature of holons and the holarchies of which they are components. This makes holarchies radically different from all the alternative forms of organisations.

While Ingber⁹⁰ does not use the words holon or holarchies, he recognises their existence by referring to 'systems' and how our bodies are 'organised hierarchically as tiers of systems within systems'.

80. Bernstein et al., 2016

81. Velinov and Densisov, 2017

82. Bodie, 2018

83. Analytica, 1992; Bernstein 1980; Craven et al., 1996; Dallas, 1997; Hock, 1999; Turnbull, 2000b, 2014b, 2020; Whyte and Whyte, 1988

84. Pirson and Turnbull, 2011, 2015; Turnbull, 2003, 2007, 2013, 2014c, Turnbull and Pirson, 2012, 2019

85. Mathews, 1996

86. Smuts, 1926

87. Simon, 1962, p.468

88. Koestler, 1967

89. Mathews, 1996, pp. 52-3

90. Ingber, 1998, p. 30

Crucially, Ingber⁹¹ notes that the 'rules of self-assembly' allow new emergent properties to arise that do not exist in the parts. In this way, he considers tensegrity as the design rules for building various life forms, consistent with the title of his article 'The architecture of life'. This provides another reason holarchies radically differ from other forms of organisations. It also suggests that tensegrity, like time, is an embedded feature of all matter and energy, as hypothesised in the concluding section.

Social scientists' knowledge gap about self-governance

This knowledge gap has been recognised by leading associations of scholars such as the Academy of Management (AOM) and the European Academy of Management (EURAM). The AOM accepted holding a 'Caucus'⁹² to consider the knowledge gap at their annual 2021 conference, while EURAM held related symposia at their annual conferences in 2021⁹³ and 2022⁹⁴ with a follow-up one programmed for 2023.⁹⁵

An earlier version of this article was presented at systems scientists' conferences and the EURAM 2022 conference. Nevertheless, for the EURAM presentation, the title was changed to make it more attractive for management scholars by removing the word 'cybernetics'. While the word 'tensegrity' would be mostly unknown, it would not have questionable connotations that can arise with the word 'cybernetics'. The title of that paper became 'Why is tensegrity a neglected organisational resource?'

Language is a problem in closing the knowledge gap about self-governance. Many words can possess ambiguous meanings. Ostrom⁹⁶ pointed out that:

'No scientific field can advance far if participants do not share a common understanding of key terms in their field'. Even the words 'systems' and 'scientist' are part of the problem. A dictionary definition of a 'scientist' is 'a person who is studying or has expert knowledge of one or more of the natural or physical sciences'. This excludes social activities like management and economic systems being scientific unless they can be defined by some physical metric.

Definitions of a 'system' can include dominant social metrics like prices, costs and profits that represent social constructs not defined by any one or more real goods or services. This denies rigorous feedback communications or reliable management of problems if no physical metrics are available to provide undisputable objective analysis. Without physical metrics, social systems lack processes to understand any physical limits introduced by the insights from the science of cybernetics, defined as 'control and communication in the animal and the machine'.⁹⁷

This cited definition excludes control and communication *external* to an animal and a machine. So, a new definition is required if we wish to apply cybernetic insights to the social activities of any living thing. Something along the lines of 'control and communication within and between biota and human-created devices'. These words provide a definition for 'the science of governance' cited above.

The need to involve 'communications' within and between entities introduces the need for transmitting, receiving and processing data. As noted above, data possess metrics described as bytes. Problems arise from using the word

91. Ibid

92. AOM, 2021

93. EURAM, 2021

94. EURAM, 2022

95. EURAM, 2023

96. Ostrom, 1986, p.4

97. Wiener, 1948

'information' to describe data when many people use the word 'information' as referring to meanings, knowledge and/or wisdom. There are no physically based metrics for such social constructs, just as there are no physically based metrics for economic value, costs or prices.

These social constructs are not required by flora, fauna any other types of life to become self-governing. The challenge for humans is to adopt natural practices and natural scientists' use to design self-governing devices. The communication, control and data processing systems in biota share identical data metrics as humans in the form of bytes.

Humans' physiological and neurological limits to transact bytes are now known and provide design criteria for how they may be best connected to achieve self-governance without needing metrics for meanings, knowledge and wisdom. This is because no change in these social constructs can occur without transacting bytes.

CALL TO ACTION

In suggesting a call to action, we need to consider the first pioneering application of cybernetics to management described above as VSM as a starting point. Beer introduced the VSM in his 1972 book that became so widely read it was republished in 1981. It is perhaps the most accepted attempt to apply systems knowledge to management. However, it failed to be widely adopted in practice. This was because its success depends upon managers' discretion and support from a higher authority like a board of directors.

Beer had been oblivious to the architecture of power in modern organisations. He advised me of

this in person on 3 August 1996 after reading the paper⁹⁸ I was presenting in Toronto. He said that he had never engaged with corporate governance. It was only around that time that the crucial role of governance was beginning to become recognised. Likewise, humans' physiological and neurological limits to transact data and information, knowledge and wisdom had yet to become widely acknowledged as a criterion for designing self-governing organisations.⁹⁹

Even today, no known education institution provides education on how to design the constitutions of organisations to provide operating advantages.¹⁰⁰ The first course in the world to do so was a 40-hour MBA elective at Macquarie University Graduate School of Business in Sydney in 2003 and 2004. The course was designed and presented by my PhD supervisor Prof James Guthrie and me. Part¹⁰¹ of this course was adopted by Columbia Law Professor Katharina Pistor in a postgraduate law course she taught at the Swiss International Law School in 2015.¹⁰²

There appears to be a mindset that corporate constitutions are irrelevant to managers, governance scholars or society. However, the 2018 call by the biggest investor in the world, holding around 10% of all global equities by value for 'A new model of corporate governance'¹⁰³ might provide an incentive for individuals to seek this knowledge to learn how a new model might best be designed and so for scholars to deliver such knowledge. This incentive was reinforced by the CEOs of the US Business Round Table (BRT)¹⁰⁴ in 2019, to adopt as their corporate purpose to 'provide benefits for all their stakeholders'. At present, they lack a credible model of governance to achieve their purpose¹⁰⁵.

98. Turnbull, 1997

99. Turnbull, 2014a

100. Turnbull, 2000a

101. Turnbull, 2015

102. Pistor, 2015

103. Fink, 2018

104. BRT, 2019

105. Bebchuk and Tallarita, 2022

A political initiative may be required to initiate change, as suggested in my book,¹⁰⁶ articles¹⁰⁷ and a working paper, 'Do we need a new model of corporate governance?'¹⁰⁸ It describes a self-funding tax incentive for shareholders to introduce stakeholder capitalism to achieve the BRT purpose. The tax benefit requires shareholders to change corporate constitutions in three ways:

1. Shareholders transfer a small fraction of their equity each year to a new class of stakeholder shares. This allows the ownership of corporations to be localised in each bioregion of the planet in which they operate by endowing resident citizens with stakeholder shares. Corporations can then become responsible for protecting and nurture the host environments of their stakeholders.
2. A division of corporate powers is introduced. Shareholders elect one board to manage the business and a second board to govern the corporation. Unlike the European two-tiered boards that appoint the management board, this simplifies directors' duties and removes their dysfunctional conflicts of self-interest in determining their own nomination, remuneration and audit. It also introduces tensegrity as the governance board is elected democratically to introduce constructive tensions with managers elected on a plutocratic basis, but whose pay and appointment are determined democratically.
3. Corporate constitutions introduce tensegrity between stakeholders and managers, allowing each stakeholder constituency to elect and resource its own advisory board providing key performance indicators for the Board of Governors on how well the management board are delivering stakeholder benefits. Shareholder primacy is maintained that now includes stakeholders. Stakeholders become co-regulators to facilitate self-governance to reduce the role of government.

The working paper provides operating details with a literature review of ten different ways of introducing 'a new model of corporate governance'. Some authors raised concerns about applying the Ostrom Design Principles directly globally. However, these can be overcome by taking the indirect approach to amplify regulation indirectly by corporations becoming 'supplementary'¹⁰⁹ co-regulators of the complex, interrelated variables degrading the global commons locally.

Endowing voting citizens with equity creates a compelling incentive for elected politicians with competing interests to support a tax incentive for investors to lead the introduction of stakeholder capitalism. Citizens typically pay higher taxes than corporations so that the tax incentive can become self-funding. Localising ownership also enriches the host country by reducing obligations to foreign investors.¹¹⁰

The endowment of citizens with corporate shares creates a process to build a universal wellbeing income for citizens. It provides a way to privatise the welfare system with less tax, less welfare and smaller governments. Compelling self-reinforcing incentives are created for political leaders, investors, CEOs and citizen voters to transform corporations and enrich democracy locally with citizen voices from the bottom-up of the firms that affect their wellbeing.

CONCLUDING REMARKS

The phenomenon of tensegrity was first identified in the 1950s by Buckminster Fuller in the sculptures of Snelson.¹¹¹ Fuller used tensegrity to create geodesic domes that covered the most significant area with the least material. Ingber noted that 'tensegrity structures offer a maximum

106. Turnbull, 1975, Appendix

107. Turnbull, 1997, 2011, 2014a, 2020, 2021c, 2022a; Turnbull and Poelina; 2022, Turnbull and Myers, 2017

108. Turnbull, 2021a

109. Ashby, 1956, p. 244

110. Penrose, 1956, p. 235

111. Snelson, 2012

amount of strength for a given amount of building material'. The theoretical contributions of this article follow up the observations of Fuller and Ingber to suggest that:

1. behavioural tensegrity provides biota with the ability to minimise its DNA to reproduce;
2. behavioural tensegrity provides biota an efficient way to become self-governing;
3. self-governance of organisations is dependent upon them possessing tensegrity;
4. tensegrity is frustrated or denied by hierarchies to deny self-governance;
5. tensegrity reveals models of human behaviour used by many scholars are not realistic;
6. tensegrity in social organisations drives adaption to sustain their survival;
7. organisations with tensegrity enrich democracy with inclusive participation by citizens;
8. transaction byte analysis provides a methodology for researching the hypotheses;
9. the science of cybernetics is extended and subsumed into the science of governance;
10. tensegrity, like the arrow of time, is an embedded emergent feature of the universe.

The practical contributions of this article are to identify how to:

1. design self-governing organisations;
2. apply the self-governing design principles of Ostrom to corporate entities;
3. transform corporate entities to become a CPR providing benefits to all citizens;
4. create a tax incentive to transform corporations to become a CPR;
5. make the tax incentive self-financing to accelerate stakeholders replacing shareholders;
6. build a universal wellbeing income for bioregional citizens to reduce government;

7. create CPRs to become global agents to counter local environmental degradations;
8. transform capitalism to establish bioregional circular eternal self-governing societies.

Research opportunities arise from the hypotheses raised in this article, with TBA providing a framework for their investigation. As bytes are ubiquitously and routinely disclosed on most electronic devices, there are many opportunities for using TBA as a research tool to investigate many other questions that social scientists may raise. As TBA can be applied to any biota, it could also be used to evaluate and compare the social behaviour within and between diverse forms of biota. The opportunity exists to replace bytes with qubits to consider complex relationships at the quantum level.¹¹²

This article has also identified how tensegrity and the ability of organisations to become self-governing is a neglected topic of scholarship and practice with social scientists and practitioners. However, natural scientists have applied this knowledge to design, build and operate self-governing automobiles and space exploration vehicles.

While academics¹¹³ have identified that 'Climate change is the most important mission for universities of the 21st Century', there is little evidence of this being recognised. While members of leading academic associations cited above have recognised a global knowledge gap in how to introduce bottom-up stakeholder-governed organisations, universities understandably resist committing their resources to sources of knowledge not created by them.

Ways of overcoming this collective academic inaction depend on their staff's informal initiatives and institutional reaction to practitioner-led initiatives. Practitioner-led initiatives have been

112. Turnbull and Poelina, 2022, p. 42

113. <https://theconversation.com/climate-change-is-the-most-important-mission-for-universities-of-the-21st-century-139214>

noted in this article, such as the US Business Round Table seeking to make their corporations a CPR to provide benefits for all their stakeholders. Also, the call from one of their members for 'A new model of corporate governance' to turn corporations into a CPR.

The conversion of established corporations into CPR organisations will likely require each to be custom designed. There are so few precedents in custom designing self-governing organisational architecture, so this may most likely require learn-by-doing processes. While this article has identified various design principles, their application could be a matter of art¹¹⁴ informed by trial and error.

A critical complementary skill to guide and expedite a learn-by-doing process is the development of techniques for assessing the integrity, quality, variety, response times and coverage of corporate channels of communication, control and decision-making required to achieve self-governance.

To develop this skill, the cohorts in those 2002–2003 MBA elective classes, mentioned earlier, were divided into three-person syndicates. Each syndicate developed and presented its own rating system to be compared and critiqued by its peers. They could then modify their self-governance rating systems to re-rate the case studies they had selected for introducing improvements. Each other syndicate would then use their rating systems to evaluate how recommended changes to corporate charters and bylaws might improve. In this way, each syndicate was exposed to a variety of case studies, self-governance rating systems and techniques for improving self-governance.

The shared learn-by-doing re-iterative processes with built-in 'trim tab'¹¹⁵ feedback corrections described above would remain valid today. Readers

interested in co-inventing an education program for self-governance architects are invited to join an online discussion group by contacting the author. When there is an interest in filling the gap in knowledge and practices of transforming capitalism to become eternally sustainable, this article could provide a resource for developing this objective.

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114. Turnbull, 2015

115. Bucky Fuller epitaph <https://www.sloww.co/trim-tab-buckminster-fuller/>

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