ARTICLE

SIMPLIFYING THE MANAGEMENT OF COMPLEXITY: AS ACHIEVED IN NATURE

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Governance scientists Dr Shann Turnbull and Prof James Guthrie AM use stakeholder firms to illustrate how to simplify the management of complexity and use natural laws to transform corporations into common good enterprises to counter global existential risks.

INTRODUCTION

This paper considers the research question: how can business organisations manage complexity simply on a comprehensive and reliable basis? More specifically, we ask: is the current dominant architecture of businesses as centralised command and control hierarchies the best fit to allow complexity to be sufficiently simplified so that humans with limited data processing abilities can reliably manage complexity?

The methodology involves using elements of complexity theory. According to Andrus,[1] complexity theory is based on 'four significant theoretical building blocks': general system theory;[2] information theory;[3] chaos theory,[4] and fractal theory.[5]

Subsumed into these building blocks is what Wiener,[6] an MIT mathematician, described as 'Cybernetics'. French physicist and mathematician

1. D.C. Andrus, 'The Wiki and the Blog: Towards a Complex Adaptive Intelligence Community', *Studies in Intelligence*, vol. 49, no. 3, 2005, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=755904, p. 3
2. L. von Bertalanffy, *General System Theory*, New York, George Braziller, 1968
3. C.E. Shannon, 'A Mathematical Theory of Communications', *Bell System Technical Journal*, vol. 27, no. 3, 1948, pp. 379-423
4. E.N. Lorenz, *The Essence of Chaos*, Seattle, University of Washington Press, 1993
5. B.B. Mandelbrot, *The Fractal Geometry of Nature*, New York City, Macmillan, 1977
6. N. Wiener, *Cybernetics: Or Control and Communications in the Animal and the Machine*, Cambridge, MIT Press, 1948

Ampère, first coined the word 'cybernetique' in his 1834 essay to describe the science of civil government.[7] This topic has taken centuries to develop with contributions in the 20th and 21st by respectively Smuts[8] and Turnbull[9] and in this article.[10]

The word cybernetics is based on the Greek for 'steersman' or 'governor'. Wiener[11] defined cybernetics as, 'the science of control and communication in the animal and the machine'.[12] As pointed out by Ashby,[13] a London neurologist, 'The truths of cybernetics are not conditional on being their being derived from some other branch of science'.

Beer[14] pioneered the application of cybernetics to management and developed his concept of 'Viable Systems Management' (VSM). Another name for cybernetic analysis was 'operations research'[15] or 'systems' thinking.[16] Beer advised[17] Turnbull that he had never extended VSM to include governance variables. This is understandable. The first textbook on corporate governance was not published until 1984[18]. As President of the World Organisation of Systems and Cybernetics, Beer encouraged Turnbull to contribute to the cybernetic literature that resulted in Turnbull's framework for designing sustainable urban communities.[19]

Shannon's contribution[20] to complexity theory was as a Bell Telephone engineer. Shannon was concerned with the engineering problems of transmitting communication signals without error. In the second paragraph of his seminal article, he makes it clear that he was not concerned with the usual meaning of the word 'information' that communicates meaning. Shannon was only concerned with the accuracy of communicating data that can be measured in 'bits', which, in turn, could communicate meaning if errors did not arise in the data.

Bits are perturbations in the matter and energy that make a difference. To avoid ambiguity, this paper will use the more common term of 'bytes' that represents eight bits of data. In contemporary times many electronic devices routinely report the volume data in units of bytes that devices may receive, process, store, or transmit. This development provides a basis for empirical research using bytes as the unit of analysis that did not exist when theories of the firm were being developed.

Information is data that provides meaning to an observer. However, different observers of identical data may obtain radically different meanings. Information is a social construct that cannot be

7. H.S. Tsien, *Engineering Cybernetics*, McGraw Hill, 1954
8. J. Smuts, *Holism and Evolution*, London and New York, Macmillan, 1926
9. S. Turnbull, 'Emergence of a Global Brain: For and from World Governance', *Working paper*, 2003, http://papers.ssrn.com/abstract_id=637401
10. S. Turnbull, 'Design Criteria for a Global Brain', *The First Global Brain Workshop*, Vrije Universiteit Brussei, Belguim, 5 July 2001, http://pespmc1.vub.ac.be/Conf/GB-0-abs.html#Turnbull
11. Weiner, *Cybernetics: Or Control and Communications in the Animal and the Machine*
12. W.R. Ashby, *An Introduction to Cybernetics*, New York, Wiley, 1957. http://pespmc1.vub.ac.be/books/IntroCyb.pdf, p. 1
13. W.R. Ashby, *An Introduction to Cybernetics*, p. 1
14. S. Beer, *Management Science: The Business Use of Operations Research*, London, Aldus Books, Doubleday, New York, 1968
15. S. Beer, *Management Science: The Business Use of Operations Research*
16. von Bertalanffy, *General System Theory*
17. 1996, August 3 meeting in Toronto, Canada where Turnbull was presenting his paper, read by Beer, on 'Stakeholder Governance: A cybernetic and property rights analysis', published in R. I. Tricker (ed.) *Corporate Governance: History of Management Thought*, Ashgate Publishing, London, 2000, pp. 401-413
18. R.I. Tricker, *Corporate Governance: Practices, Procedures, and Powers in British Companies and their Boards of Directors*, Gower, London, and the Corporate Policy Group, Oxford, 1984
19. S. Turnbull, 'A Framework for Designing Sustainable Urban Communities', *Kybernetes: The International Journal of Systems & Cybernetics*, vol. 36, no. 9-10, 2007, pp. 1543-1557, https://dblp.org/pers/hd/t/Turnbull:Shann
20. Shannon, 'A Mathematical Theory of Communications'

reliably defined and so measured in physical units. Other related social constructs are 'knowledge' and 'wisdom'. Knowledge can be simplistically described as how to use information; wisdom can be described as when to use knowledge. While information, knowledge, and wisdom cannot be metered, no change in their status or distribution can occur without the transaction of bytes.

Transaction Byte Analysis (TBA), developed by Turnbull,[21] provides a basis for grounding aspects of the social sciences in the natural sciences. This is because no interaction between any living things can occur without the transaction of bytes. Also, the emergence of any information, knowledge or wisdom within or between living things requires the transaction of bytes.[22] The creation, nature, and characteristics of living things are determined by the bytes embedded in their DNA and how these interact with their environment. These interactions generate instincts and behaviour patterns to survive birth and dynamic unknowable complex environments. TBA can be used to explain why DNA embeds complex contrary behaviour into creatures as the most efficient way to generate variety to allow them to survive birth and become self-governing in complex environments. TBA has also been used to establish 'The science of corporate governance', and more generally 'the science of governance'.[23]

The British Telecom research laboratories pioneered measuring the capacity of humans to transact bytes by our five senses of touch, taste, smell, sound and sight.[24] Kurzweil,[25] an MIT speech recognition scientist, identified the neurological limits for our brains to receive, store, process, and transmit bytes. These limits identify the degree to which complexity needs to be simplified, to allow individuals of any species to survive and thrive in dynamic complex unknowable environments reliably.

As noted by Simon,[26] in the first words of his seminal essay on *The Architecture of Complexity*: 'There are some properties common to many complex systems'. Their emergence in biology can be explained from the need to economise bytes and so the materials and energy needed to create and maintain life. The ability of innate materials to learn how to reproduce their patterns of energy and materials with adaptive variations to create and maintain reproducible life crucially depends upon a sustainable data memory and data processing capability. The human brain vividly illustrates the importance of the need to economise bytes to minimise data processing materials and energy. While our brains may be only two per cent of our body weight, they surprisingly consume ten times more energy than the rest of the body.[27] Ashby[28] notes: 'The gene-pattern, as a store of channel variety, has limited capacity. Survival goes especially to those species that use the capacity efficiently'.

21. S. Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples', PhD Thesis, Macquarie Graduate School of Management, 2000, https://papers.ssrn.com/abstract_id=858244
22. S. Turnbull, 'Grounding Social Theory in the Natural Sciences', Research Committee 33 on Logic and Methodology in Sociology, Fundamental Issues in Social Research, XVth World Congress of Sociology, International Sociology Association, July 12, 2002, http://ssrn.com/abstract_id=321140;
S. Turnbull, 'Grounding Sociology in Cybernetics', Research Committee 51 in Socio-cybernetics, New Paradigms for Understanding Society, XVth World Congress of Sociology, International Sociology Association, July 13, 2002, https://ssrn.com/abstract=321203
23. S. Turnbull, 'The science of corporate governance' *Corporate Governance: An International Review*, vol. 10, no. 4, 2002, pp. 256-272, http://ssrn.com/abstract_id=316939
S. Turnbull, 'The Science of Governance: A Blind Spot of Risk Managers and Corporate Governance Reform, *Journal of Risk Management in Financial Institutions,* vol. 1, no. 4, 2008, pp. 360-368, https://papers.ssrn.com/abstract_id=1742584
24. P. Cochrane, 'Hard-drive: Bandwidth and brandwidth', *Telegraph*, 6 April 2000, https://www.telegraph.co.uk/technology/4748353/Hard-drive-Bandwidth-and-brandwidth.html
25. R. Kurzweil, *The Age of Spiritual Machines*, New York, Penguin Group, 1999
26. H.A. Simon, 'The Architecture of Complexity', *Proceedings of the American Philosophical Society*, vol. 10, no. 6, 1962, pp. 467-482
27. *The Physics Factbook*, https://hypertextbook.com/facts/2001/JacquelineLing.shtml
28. Ashby, *An Introduction to Cybernetics*, p. 270

Simon[29] used probability analysis to explain in awkward language how the complexity of life needed to be created from 'sub-assembles', 'stable intermediate forms', 'able to maintain their own existence', and in 'nearly decomposable systems in which interactions among the sub-systems are weak, but not negligible'. Introducing the concept described by Koestler[30] as a 'Holon', allows the awkward language used by Simon to be dispensed with as is explained in the following section.

Words are the tools of thinking. New words are required to introduce new ideas. Complexity theory introduces the need for adopting new words to create parsimony in thinking, to facilitate analysis and communication. There is also the need a need to use established words in different ways to describe processes found in complexity theory. Examples are described by Andrus,[31] who describes six processes of complexity theory with the words: (1) self-organisation; (2) emergence; (3) relationships; (4) feedback; (5) adaptability, and (6) non-linearity.

Other processes could be added. But some crucial missing concepts are: 'tensegrity', 'holon', and 'holarchy'. These introduce powerful explanatory concepts for understanding, evaluating, and managing complexity. A search of the titles, abstracts, and keywords of over 861,000 articles archived in the Social Science Research Network suggests that these concepts have not become widely recognised as being part of complexity theory. Alternatively, there exist the possibility that authors have neglected to highlight these words and/or have used different words to describe similar concepts. The awkward language used by Simon,[32] and as identified with other authors by Mathews[33] provide examples. Mathews in turn does not use the word 'Tensegrity' but this is what he is referring to in describing the defining features of Holons. Instead Mathews refers to Holons possessing: 'Centralisation/decentralisation'; 'Bottom-up/top-down'; 'Autonomous/integrated'; and 'Order/Ambiguity'.[34]

To fill or explain this apparent gap in complexity theory, the following section discusses tensegrity, holons, and holarchy. The third section considers the limitations of managing complex activities in public, private, non-profit, or government sectors using hierarchies. The fourth section describes network organisations and considers their ability to simplify the management of complexity reliably. The concluding section identifies why and how elements of an ecological form of governance could be introduced in practice.

TENSEGRITY, HOLONS, AND HOLARCHY

Tensegrity

This word describes how seemingly opposite or contrary characteristics or forces may be complementary, interconnected, and interdependent. Neuroscientists Kelso and Engstrøm[35] describe how nature, in the form of DNA, hard-wires humans to be both competitive~cooperative, selfish~generous, suspicious~trusting, and so on. Kelso and Engstrøm introduced the tilde '~' symbol to indicate such relationships.

29. Simon, 'The Architecture of Complexity'
30. C.O. Koestler, *The ghost in the machine*, London: Hutchinson, 1967
31. Andrus, 'The Wiki and the Blog: Towards a Complex Adaptive Intelligence Community', pp. 7-9
32. Simon, 'The Architecture of Complexity'
33. J. Mathews, 'Holonic Organizational Architectures', *Human Systems Management*, vol. 15, 1996, pp. 27-54, pp. 36-38
34. J. Mathews, 'Holonic Organizational Architectures', pp. 52-53
35. J.A.S. Kelso and D.A. Engstrøm, *The Complementary Nature,* Cambridge, MA, MIT Press, 2006

Buckminster Fuller[36] combined the words 'Tension' and 'Integrity' to create the word 'Tensegrity'. The compression and tension struts of Fuller's geodesic domes, allows the greatest area to be covered by the least weight of materials. Like geodesic domes tensegrity allows humans to obtain a 'requisite variety'[37] of communication and control responses using the least amount of data processing materials and energy to transact bytes to survive complexity.

Not many stable, let alone dynamic structures could be constructed from just all the bones in a human body that performs best in compression. Likewise, for all the muscles in a human body that best perform in tension. Combining these contrary~complementary types of materials results in radically different characteristics to emerge for the whole system. Harvard biologist Ingber[38] described tensegrity as 'The architecture of life'.

Tensegrity allows DNA to efficiently transmit and generate a requisite variety of complexity for the survival of its reproduction in complex environments. While computers now exceed human abilities in data processing, they have not yet matched the compactness, energy efficiency and mobility of human neurological data processing.

Bohm,[39] a quantum physicist, suggested that tensegrity is the architecture of the universe. Photons of light exhibit properties of being either a particle or a wave. Similar duality exists with quantum states of 'superposition'.[40] Tensegrity generates variety. Evolutionary processes require variety to generate complexity. A simple example of how variety can be generated from identical sub-components with contrary~complementary characteristics is illustrated by the periodic table of all known atomic elements. Each element is created from different combinations of three sub-components call protons, neutrons, and electrons.

Tensegrity creates the most efficient way to either create or survive complexity. It reflects the ancient Chinese idea of Yin and Yang, providing a healthy life. It is a feature that could improve the health, efficiency, resiliency, and survivability of organisations, yet management theorists and most practitioners have neglected it, despite its benefits. Tensegrity radically challenges a mindset seeking to promote cooperation, teamwork, and accountability only upwards, and control only downwards.

Holons and holarchy

Protons represent 'holons' that are simultaneously a 'whole' and a 'part'. Protons represent a 'whole' of its sub-atomic particles described as 'quarks' and 'gluons'.[41] Protons, in turn, become a 'part' of an atom. Different atoms, in turn, combine to form different types of molecules. The proton's sub-atomic particles, protons, and the atoms they create form a 'holarchy'. A holarchy is quite different from a command and control hierarchy because its holonic parts can exist independently and *in turn reproduce* contrary~complementary characteristics.

A defining feature of holons is that they possess tensegrity. Holons also possess relative autonomy of the system of which they are a part. They demonstrate tensegrity by also possessing system dependence. As a result of their autonomy~dependence, no part of the system

36. R.B. Fuller, 'Tensegrity', *Portfolio and Art News Annual*, vol. 4, 1961, pp. 112-127, 144, 148
37. Ashby, *An Introduction to Cybernetics*, p. 211
38. D.E. Ingber, 'The Architecture of Life', *Scientific American*, January 1998, pp. 30-39
39. D. Bohm, *Wholeness and the Implicate Order*, London, Routledge, 1980
40. Cornell University, https://arxiv.org/abs/1901.02810
41. A. Deshpande and R. Yoshida, 'The Deepest Recesses of the Atom', *Scientific American*, June 2019, pp. 26-33

will possess complete information about any other part.[42] Holons can exhibit various forms of tensegrity by combining opposite characteristics not found in hierarchies like centralisation~decentralisations and top-down~bottom-up characteristics. Mathews[43] describes how holons may undertake different functions at different levels of a holarchy. Some determine 'what holon do', others, 'how their tasks are combined' or 'why some tasks are accomplished and not others'.

Concepts illustrated by VISA Inc.

Dee Hock, the founding Chief Executive Officer of the VISA International credit card organisation invented his name for holons by combining the words 'chaos' and 'order' to create the word 'chaord'. Hock[44] defined a chaord in two ways:

1. Any self-organising, self-governing, adaptive, nonlinear, complex organism, organisation, community or system, whether physical biological or social, the behaviour of which harmoniously blends characteristics of both chaos and order.
2. An entity whose behaviour exhibits observable patterns and probabilities not governed or explained by the rules that govern or explain its constituent parts.

Hock described 'chaordic' in three ways:

1. The behaviour of any self-governing organism, organisation or system, which harmoniously blends characteristics of order and chaos.
2. Patterned in a way dominated by neither, chaos, or order.
3. Characteristic of the fundamental organising principle of evolution and nature.

VISA Inc was created by Hock in 1970 as a producer~consumer cooperative of competing~cooperating US banks. The banks consumed the credit card services produced by VISA that was created by cooperating with their credit card competitors. Hock[45] explained that the organisation 'had multiple boards of directors within a single legal entity, none of which can be considered superior or inferior, as each has irrevocable authority and autonomy over a geographic or functional area'. Consistent with the observation above by Mathews,[46] Hock observed: 'No part knew the whole, the whole does not know all the parts, and none had any need to. The entity, like millions of other chaordic organisations, including those we call body, brain, forest, ocean and biosphere, was largely self-regulating'.[47]

In firms with only a single board, coordination between different functional and geographic activities requires delegation and the establishment of some form of formal or informal 'matrix'[48] organisation. This requires executives responsible for the integration to increase their data processing, information, and knowledge.

The significance of the observation by Hock and Mathews about the compartmentalisation of data results in a substantial reduction in the need for transacting, storing, and processing bytes, data, information, knowledge, and wisdom. Economising bytes provides ways to economise materials and

42. Mathews, 'Holonic Organizational Architectures', pp. 39-40
43. Mathews, 'Holonic Organizational Architectures', p. 41
44. D. Hock, *Birth of the Chaordic Age*, Berrett-Koehler Publishers, San Francisco, 1999
45. D. Hock, *Birth of the Chaordic Age*, p. 191
46. Mathews, 'Holonic Organizational Architectures', pp. 39-40
47. D. Hock, *Birth of the Chaordic Age*, p. 191
48. P. Lasserre, *Global Strategic Management*, 4th Edition, New York, Palgrave Macmillan, 2018, p. 405

energy and also simplify complexity. Mathews[49] noted: 'The reduction in data complexity, achieved by the holonic architecture is prodigious'. This is why the adoption of holonic communication and control architecture becomes a fundamental strategy for comprehensively and reliably simplifying complexity.

Each participating bank had its VISA board to control the issue of credit cards that competed with all other participating banks cooperating in adopting a common name, brand, marketing, operating functions, and data processing. The competing banks cooperated in the appointment of 'compound boards'[50] to control the various common functions.

Each bank represented a self-governing unit that in turn was part of a self-governing organisation subject to competitive~cooperative compound relationships. In these ways, the VISA organisation could be described in the words of the Ostroms[51,52,53] and Ostrom and Allen[54] as 'polycentric compound republics'.

Other stakeholder-controlled firms like the employee controlled John Lewis Partnership that has a board for each store in the UK and the stakeholder controlled Mondragón Corporacion Cooperativa (MCC) in Spain that has boards for each cooperative component, also meet the test of forming polycentric compound republics. These two firms, like VISA, possess numerous boards of directors and/or control centres creating distributed intelligence and a special type of network governance. Turnbull[55] described this special type of network governance as 'ecological' because it represents the architecture of natural systems.

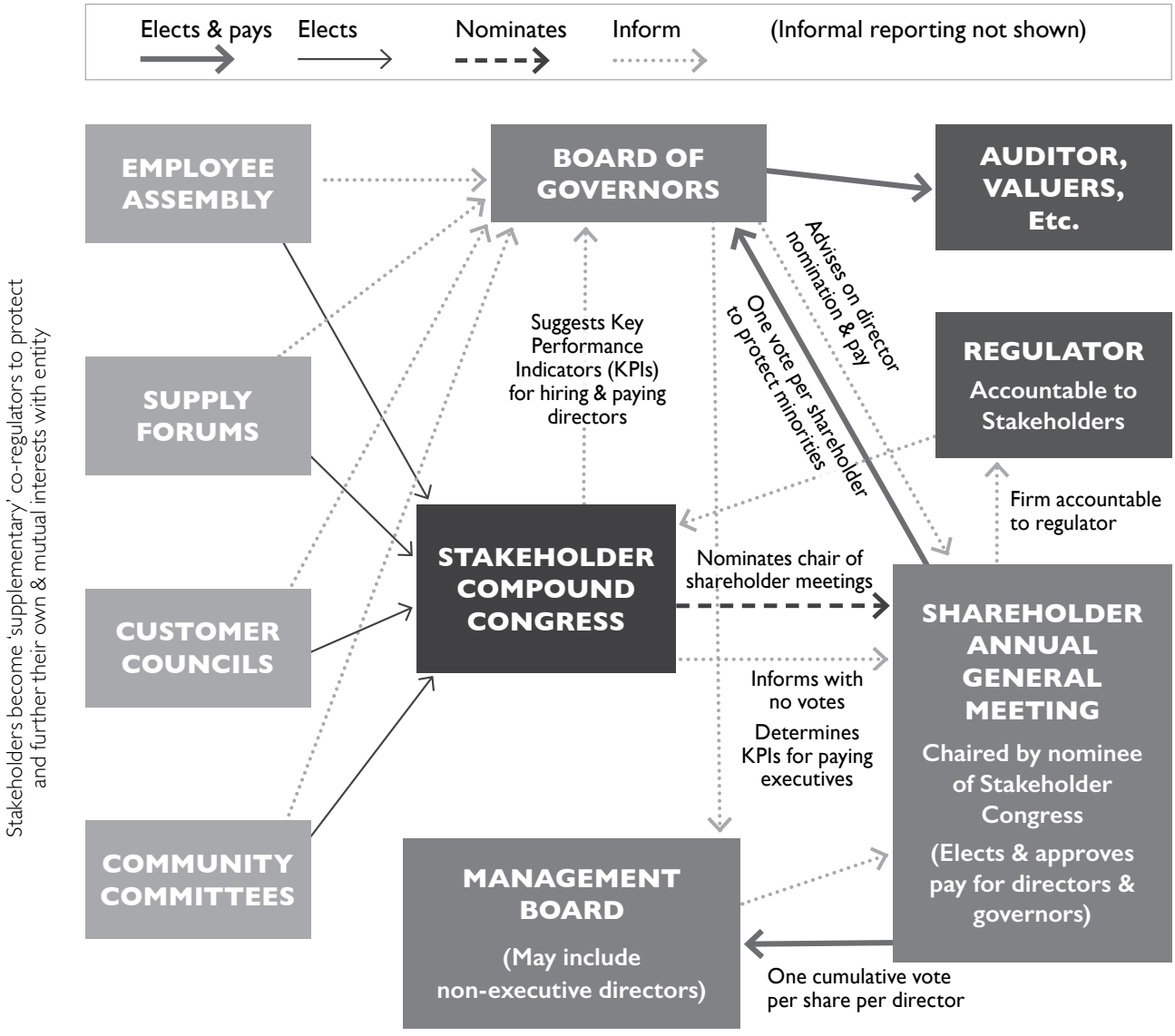
Ecological governance is radically different from the hierarchical paradigm implicitly assumed by graduate schools of business, management, and government. Instead of relying only on top-down command and controls, ecological governance introduces competing~cooperative bottom-up direction and accountability, as indicated in Figure 1. Refer to 'Employee Assembly', 'Supply Forums', 'Customer Councils' and 'Community Committees' that also represent 'Polycentric Republics' as referred to above.

The human brain provides an illustration. Our brain has no Chief Executive Neuron.[56] Different parts of the brain compete for decision-making dominance according to human internal existential needs and external risks and opportunities.[57,58,59] Ecological governance explains how millions of very small-brained ants can make complex decisions from the bottom up about when, where, and how to design, build, operate, and maintain their complex homes.[60]

49. Mathews, 'Holonic Organizational Architectures', p. 30
50. Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples, p. 27
51. E. Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press, 1990
52. E. Ostrom, 'A Polycentric Approach for Dealing with Climate Change', *World Bank: Policy Research Working Paper 5095*, 2010, http://documents.worldbank.org/curated/en/480171468315567893/pdf/WPS5095.pdf
53. V. Ostrom and E. Ostrom, 'Public Choice: A Different Approach to the Study of Public Administration', *Public Administration Review*, vol. 31, no. 2, 1971, pp. 203-216
54. V. Ostrom and B. Allen, *The Political Theory of a Compound Republic: Designing the American Experiment*, Plymouth, UK, Lexington Books, 2008
55. S. Turnbull, 'A Vision for an Eco-Centric Society and How to Get There', The Ecological Citizen, vol. 1, no. 2, 2018, pp.141-142, http://www.ecologicalcitizen.net/pdfs/Vol%201%20No%202.pdf
56. Kurzweil, *The Age of Spiritual Machine*s, p. 80
57. J.A.S. Kelso, *Dynamic Patterns: The Self-Organization o Brain and Behavior*, Cambridge MA, MIT Press, 1995
58. J.A.S. Kelso, G. Dumas, and E. Tognoli, 'Outline of a General Theory of Behavior and Brain Coordination', *Neural News*, vol. 37, 2013, pp. 120-131
59. NINDS, National Institute for Neurological Disorders and Stroke. The Architecture of the Brain, 2018, https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Know-Your-Brain#The%20Architecture%20of%20the%20Brain
60. D. Attenborough, *The Empire of the Ants*, [BBC Documentary], 2019, https://www.youtube.com/watch?v=RdPsVpD6b08

FIGURE 1:[61] Ecological governance described by Ostrom can make corporations a 'common good' benefiting all stakeholders as sought by worlds' biggest investor (Fink 2018)

Separation of governance powers from management allows independent bottom-up and outside-in stakeholder intelligence to integrate governance into Corporate Social Responsibilities to monitor and control misconduct. Systemic contestability of decisions protects and nurtures with less costs the interests of stakeholders, the firm, and society.



For publicly traded, large private firms, non profits and government corporations to make shareholders and regulators responsible for the wellbeing of stakeholders

61. Developed by the author in various forms from 'Figure 5, Stakeholder council', in: S. Turnbull, 'Best practise in the Governance of GBEs', in J. Guthrie (ed.), *Making the Australian Public Sector Count in the 1990's*, Sydney, IIR Conferences, 1995, p. 105

Holonic governance in nature and society

Field Marshal Jan Smuts[62] was the first to note the holonic architecture of natural systems. He wrote his book *Holism and Evolution* between being Prime Minister of South Africa on two occasions. His biographer, Crafford,[63] described his ideas in the following way:

> **It had very much in common with his philosophy of life as subsequently developed and embodied in his Holism and Evolution. Small units must develop into bigger wholes, and they in their turn again must grow into larger and ever-larger structures without cessation. Advancement lay along that path. Thus the unification of the four provinces in the Union of South Africa, the idea of the British Commonwealth of Nations, and, finally, the great whole resulting from the combination of the peoples of the earth in a great league of nations were but a logical progression consistent with his philosophical tenets.**

The nested networks of stakeholder governed cooperative in the Basque area of Spain, described at the MCC grew similarly by combing smaller units, a process extended to a global level by Turnbull.[64, 65] Simon[66] explained the advantage of this approach. He used probability analysis to suggest how the complexity of life could have been established similarly by federating sub-ordinate components in different ways as occurs in the periodic table. This process allows contrary~complementary subordinate components to be selected to sustain the establishment of tensegrity in higher orders of a holarchy that allows the process to be repeated. No such variety is created and replicated in command and control organisations. They represent order without also possessing the variety of chaos required for discovering how to manage complexity simply and create reproducible adaptations to do so. The MCC illustrates ecological governance in a much richer way than VISA.

The creation and maintenance of holarchic organisations are dependent on assembling subcomponents that create tensegrity. As noted above, humans are hardwired to possess contrary~complementary behaviour to meet the test of being a Holon. Such contrary behaviour is not required in command and control hierarchies that depend upon subservience and obedience. This denies hierarchies accepting or using tensegrity to create variety to manage complexity. Individuals and organisations that possess tensegrity obtain stability~agility to cope with challenges from unknowable dynamic complex environments with the capability of adaption to sustain their existence. The existence of life provides the truth of this statement.

Another fundamental requirement for individuals or organisations to manage complexity is to possess a 'requisite' variety of communications and control channels. The profound implications of the natural laws of requisite variety identified by Shannon[67] and Ashby[68] are discussed in the following sections with their implications for hierarchical organisations.

LIMITATIONS IN MANAGING COMPLEXITY WITH HIERARCHIES

Theory of Firms as Hierarchies

The theory of a firm developed by Coase[69] was limited to organisations that possessed an 'authority system', 'master and servant' or employer and employee relationship as found in command and

62. Smuts, *Holism and Evolution*
63. F.S. Crafford, *Jan Smuts: A Biography*, Kessinger Publishing, 1943, p. 15
64. Turnbull, 'Design Criteria for a Global Brain'.
65. Turnbull, 'Emergence of a Global Brain: For and from World Governance'
66. Simon, 'The Architecture of Complexity'
67. Shannon, 'A Mathematical Theory of Communications'
68. Ashby, *An Introduction to Cybernetics*
69. R.H. Coase, 'The Nature of the Firm', *Economica*, vol. 4, no. 16, p. 403, 1937, https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1468-0335.1937.tb00002.x

control hierarchies. Coase reasoned that such firms exist because instructing employees how to make a complex product can reduce cost more than transacting through market contractors for its components. Williamson[70] developed this theory of hierarchical firms to create what is referred to as Transaction Cost Economics (TCE). Williamson[71] recognised the existence of the MCC and the 'dilemma' its non-hierarchical architecture created for TCE.

At a time without electronic devices, ubiquitously reporting bytes, Williamson[72] explicitly recognised the importance of data processing in developing a theory of a firm. He stated: 'Bounded rationality involves neurophysiological limits on the one hand and language limits on the other. The physical limits take the form of rate and storage limits on the powers of individuals to receive, store, retrieve, and process information without error.'

Williamson[73] even noted that 'groups may also be formed to economise information costs'. Williamson[74] also developed 'An information processing' viewpoint to describe the need for multi-divisional (M-form) firms by stating: 'the problem of organization is precisely one of decomposing the enterprise in efficient information processing'. Ecological governance used by nature achieves this objective as illustrated by VISA avoiding the complexity of a matrix structure and the MCC illustrating how to decompose decision making of a single board into many boards as illustrated in the Tables presented below.

Coase[75] also recognised that as the size of firms increased 'there may be decreasing returns to the entrepreneur' from 'the costs of organising'. These costs include data processing in hierarchical firms to which the analysis was limited. Hierarchies develop because of the limited ability of managers to reliably supervise and mentor a large number of subordinates for whom they are directly responsible. To avoid information overload, managers limit their span of control and allow their subordinates to appoint sub-mangers to create a hierarchy.

Why Hierarchies Can Only Simplify Complexity Incompletely

Table 1 assumes a span of control of eight subordinates to indicate only the size of a firm. The crucial assumptions made in constructing the table are: (1) only half the data available to lower level workers are communicated up the chain of command; and (2) errors in reporting only affect 15% of the data. This means the volume of correct data communicated to a superior becomes 85% of 50% = 42.5%. If there are four levels of communications to the CEO, then the correct data obtained by the CEO is only 6.3%; hence 96.7% of the data available is missing or incorrect.

The communication problem can be illustrated by the party game of 'telephone'. In this game, a chain of four or more people, have to relay a message privately from one to another as accurately as possible. Even with the best intentions, the message reported at the end of the chain can be quite different from the message revealed to the audience at the end by the first member in the chain.

In command and control hierarchies, where the pay and tenure of those reporting may be determined by the information being reported, a compelling incentive exists, consciously or unconsciously, to distort, bias, misreport and omit bad news. The missing or wrong information may have existential consequences for the business. This indicates why and how hierarchies can be prone to simplify

70. O.E. Williamson, *Markets and Hierarchy: Analysis and Anti-trust Implications*, NY, Free Press, 1975
71. O.E. Williamson, *The Economic Institutions of Capitalism*, NY, Free Press, 1985, p. 265
72. Williamson, *Markets and Hierarchy: Analysis and Anti-trust Implications*, p. 21
73. Williamson, *Markets and Hierarchy: Analysis and Anti-trust Implications*, p. 42
74. Williamson, *The Economic Institutions of Capitalism*, p. 283
75. Coase, 'The Nature of the Firm', p. 394

TABLE 1[76]

Hierarchies simplify complexity incompletely with errors

Decision makers lose data, information, knowledge, and wisdom of their stakeholders

HIERARCHY	DATA UPWARDS			EMPLOYEES	
Sectors Private or public Citizens/legislature	**Volume:** Loss 50% per level	**Correct:** 85% of lower level	**Missing or wrong meaning**	**Say span of eight**	
				Per level	Accumulated total
Shareholder/Minister	Negligible	Unreliable	Unknown		
Board of directors	3.1%	1.4%	98.6%		
Chief Executive Officer	6.3%	3.3%	96.7%	1	1
Senior management	12.5%	7.7%	92.3%	8	9
Middle management	25.0%	18.1%	81.9%	64	73
Team leaders	50.0%	42.5%	57.5%	512	585
Workers	100.0%	100.0%	0.0%	4,096	4,681

complexity incompletely and so dangerously. It could explain the 'killing of the balanced scorecard'.[77]

Hierarchies Introduce Excessive Power to Facilitate Corruption Without Challenge

Another problem in hierarchies is the concentration of power. Corporations controlled by a single board of directors obtain both the power to manage the business and the power to govern the corporation. The governance powers involve: nominating directors, controlling meeting of shareholders who vote on director appointment and pay, counting the votes, deciding which votes are acceptable, and deciding how to vote open proxy forms, nominating, managing and paying the auditor who judges the accounts with absolute power to identify and manage systemic and operational conflicts of interest.

There is no ethical commercial need for directors who manage businesses also to possess powers to govern the corporation. Separation of powers is a crucial condition precedent for simplifying complexity. It makes possible the introduction of distributed intelligence and decision making to minimise data processing overload. Systemic checks and balances are introduced, as are found in political systems that seek to promote democracy. But crucially the division of powers allows executives and the business to possess tensegrity to generate requisite variety to manage and adapt to complexity.

Venture capitalists provide proof that a division of power does not jeopardise business operations, even when business risks are systematically greater at their start-up stage. It is standard practice for venture capitalists to agree with shareholders to take over governance power in return for providing

76. Based on an analysis by Downs, A., *Inside Bureaucracy*, Little Brown & Co., Boston, 1967, pp. 116-118

77. C. Nielsen, M. Lund, and P. Thomsen, 'Killing the Balanced Scorecard to Improve Internal Disclosure', *Journal of Intellectual Capital*, vol. 18, no. 1, 2017, pp 45-62

equity funding. Some bankers, even when lending money with security, may also make it a condition of the loan that they possess some governance powers. These are typically vetoed powers on what their funds can be used for, the nomination or tenure of directors, and their remuneration.

The reason why venture capitalists and bankers involve themselves in governance powers can be explained by the observation of Lord Acton:[78]

> **Power tends to corrupt, and absolute power tends to corrupt absolutely. Great men are almost always bad men, even when they exercise influence and not authority, still more when you superadd the tendency or the certainty of corruption by authority.**

This insight suggests that all unitary boards systemically facilitate corruption of their directors, their organisation, and so society. Corporate governance pioneer Tricker[79] points out that unitary boards allow directors 'to mark their exam papers'. Such systemic conflicts of self-interests are widely accepted in Anglophone jurisdictions and even promoted by so-called 'prudential' regulators. This explains why executives in such jurisdictions lose their moral compass to understand what is wrong – a point systemically highlighted by the Australian Royal Commission into misconduct in the banking, superannuation and financial services industry.[80] The costs for correcting the industry's wrongdoing are expected to reach $A10 billion.[81]

Hierarchies Become Subject to Groupthink

Even if conflicts of self-interest are not present, the efficacy of hierarchies is dependent upon the subservience of subordinates. Command and control hierarchies are dependent on obedience. It can be career threatening to question orders, introduce a variety of thought or action, and, especially, to become a whistleblower. This provides a compelling career incentive to become a team player by adopting 'groupthink'. In a commissioned submission to the Royal Commission, Professor Sah[82] pointed out that groupthink can lead to 'moral disengagement' ... 'vindicating immoral systemic practices' to 'provide exonerations for each other'.

The effect of groupthink on firm performance is a concern of BlackRock Inc. BlackRock is publicly traded on the New York Stock Exchange and is the biggest investor in the world with $US6.4 trillion under management. Its co-founder, chairman and CEO, Larry Fink[83] wrote to the CEOs of his investee companies to raise his concerns that boards of directors could 'succumb to groupthink or miss new threats to a company's business model'. He wanted 'a new model for corporate governance', one that must: 'benefit all of their stakeholders, including shareholders, employees, customers, and the communities in which they operate'.

The idea that corporations should do no harm and promote the common good is not new in the US. 'Over several decades starting 1844, nineteen states amended their constitutions to make corporate charters subject to alteration or revocation by

78. Lord Acton, 1887, letter written to an ecclesiastical scholar in the context of not supporting papal infallibility, April, https://en.wikipedia.org/wiki/John_Dalberg-Acton,_1st_Baron_Acton
79. R.I. Tricker, 'New Frontiers for Corporate Governance', CSJ, Hong Kong Institute of Charted Secretaries, January 2011, http://www.bobtricker.co.uk/assets/bob-tricker---new-frontiers-for-corporate-governance.pdf
80. Royal Commission, *Royal Commission into Misconduct in the Banking, Superannuation and Financial Services Industry*, Final Report, February 2019. https://financialservices.royalcommission.gov.au/publications/Pages/default.aspx
81. J. Eyers, 'Bank Compensation Costs Could Hit $10b', *Australian Financial Review*, 14 May 2019, https://www.afr.com/business/banking-and-finance/bank-compensation-costs-could-hit-10b-20190513-p51mt6
82. S. Sah, *Conflicts of Interest and Disclosure*, Research Paper, November 1, 2019, p. 5, https://financialservices.royalcommission.gov.au/publications/Pages/default.aspx
83. L. Fink, 'Larry Fink's Letter to CEO's, A sense of purpose', BlackRock 2018, https://www.blackrock.com/corporate/investor-relations/2018-larry-fink-ceo-letter

legislatures.'[84] In 1894, at the request of the Central Labor Union of New York City, the State Supreme Court revoked the charter of the Standard Oil Company of New York.[85]

In contemporary times shareholders, directors, and managers typically see their duty to maximise shareholder benefits rather than share benefits with their stakeholders. The perception has arisen that stakeholder interests are subject to, or are in conflict with, the interest of shareholders. The power relations in corporate hierarchies support this view. A key observation of the Royal Commission[86] was 'the asymmetry of power and information between financial services entities and their customers'. The Royal Commission[87] noted that consumers were exploited by their financial service entities 'because they could'. However, no recommendation was made to challenge the industry's excess power by introducing elements of ecological governance, as illustrated in Figure 1 with details in Turnbull.[88]

Similar conflicts of interest occurred in pre-modern societies when the short-term interests of individuals or groups to over exploit common good hunter-gathering resources could deny their benefits for everyone. This problem is referred to as 'the tragedy of the commons'. Elinor Ostrom[89] was awarded the Nobel Prize in 2009 for identifying how a special type of governance architecture described as 'polycentric compound republics' could avoid the tragedy of the commons. This ancient idea is now described as 'a new way to govern'[90] that is referred to as 'ecological' in Turnbull[91] and Turnbull and Pirson[92] for the reasons described in this article.

Hierarchies Lack Reliable Communication and Control Channels

Hierarchies not only lack variety to create tensegrity but they also lack variety to reliably and simply communicate and control complexity. This observation, with the 'Missing or wrong meaning' shown in Table 1, is sufficient to explain why hierarchies are systemically unable to reliably detect and communicate and control complexity. It explains the observations of Hock cited later in this article and why existential risks to society have become a wicked problem.

Like all systems in the universe, humans depend upon the integrity of stability that is challenged by environments creating tension for change. Hierarchies, in the public or private sectors, not subject to systemic challenge become stagnant, change resistant bureaucracies like political dictatorships.

Shannon's[93] Law of Requisite Variety of communications channels to increase the reliability of signals as much as desired and Ashby's[94] related Law of Requisite Variety of control channels to increase the reliability of controlling complexity as much as desired provide the foundations for establishing the natural sciences of: regulation, cybernetics, governance, and self-governance.

84. R.L. Grossman and F.T. Adams, *Taking Care of Business: Citizenship and the Charter of Incorporation*, Cambridge, MA, Charter Ink, 1993, https://www.ratical.org/corporations/TCoB.pdf, p. 13
85. Grossman and Adams, *Taking Care of Business: Citizenship and the Charter of Incorporation*, p. 17
86. Royal Commission, *Royal Commission into Misconduct in the Banking, Superannuation and Financial Services Industry*, p. 1
87. Royal Commission, *Royal Commission into Misconduct in the Banking, Superannuation and Financial Services Industry*
88. S. Turnbull, 'Causes and Solutions for Misconduct in the Financial Services Industry', *Law and Financial Markets Review*, 2019, April, https://doi.org/10.1080/17521440.2019.1602694
89. Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*
90. S. Turnbull, *A New Way to Govern: Organisations and Society after Enron*, Public Policy Booklet No. 6, London, New Economics Foundation, 2002, https://ssrn.com/abstract=319867
91. S. Turnbull, 'How Might Network Governance Found in Nature Protect Nature?' *European Company Law*, vol. 11, no. 2, pp 98-102, 2014, https://www.kluwerlawonline.com/preview.php?id=EUCL2014019
92. S. Turnbull and M. Pirson, 'The Future of Management: Network Governance', *European Financial Review*, 1 May 2019, http://www.europeanfinancialreview.com/the-future-of-management-network-governance/
93. Shannon, 'A Mathematical Theory of Communications'
94. Ashby, *An Introduction to Cybernetics*, p. 206

Further to the statement of Ashby[95] that 'cybernetics has its own foundations', he proves mathematically that the Law of Requisite Variety 'owes nothing to experiment' or the nature of variety being in question or the processes of regulation or control.[96] 'The law states certain events are impossible.'[97] The simplistic articulation of the law is intuitively sensible that 'only variety can control variety'.[98] More formally Ashby states that: 'only variety in R [regulator] can force down the variety due to D [disturbance]'.

Ashby's[99] Law of Requisite Variety of control also means that:

> **R's capacity as a regulator cannot exceed R's capacity as a channel of communication. In the form just given, the Law of Requisite Variety can be shown in exact relation to Shannon's theorem 10, which says that if noise appears in a message, the amount of noise that can be removed by a correction channel is limited to the amount of information [bytes] that can be carried by that channel.**

The implications of the laws of requisite variety are profound in modern societies governed by command and control hierarchies used by governments to regulate the complexity of businesses and individuals, or for CEOs of large complex organisations in the private, non-profit, or government sectors. It denies the ability of government regulators to achieve their objectives reliably. Likewise, the law denies CEOs of large complex hierarchal entities to reliably comply with regulators and/or to reliably establish and maintain quality in providing goods and/or services or providing benefits for 'all stakeholders'.[100]

The Law of Requisite Variety explains the insights of Dee Hock, the founding CEO of the credit card company VISA Inc. Hock[101] stated:

> **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.**

Hierarchies exacerbate the problem of: 'Regulating the very large system'[102] because it is impossible to directly 'amplify' regulation. Ashby[103] states that an amplifier 'in general is a device that, if given a little of something will emit a lot of it'. 'The Law of Requisite Variety, like the laws of Conservation of Energy, absolutely prohibits any direct and simple magnification but it does not prohibit supplementation.'[104] For example, one person may take a day to move many heavy objects that could take the same person driving a crane to achieve in a fraction of the time by supplementing his energy from another source.

Ashby[105] gives an example of a person wanting to keep the temperature of a water bath constant by

95. Ashby, *An Introduction to Cybernetics*, p. 1
96. Ashby, *An Introduction to Cybernetics*, p. 208
97. Ashby, *An Introduction to Cybernetics*, p. 209
98. Ashby, *An Introduction to Cybernetics*, p. 207
99. Ashby, *An Introduction to Cybernetics*, p. 211
100. Fink, 'Larry Fink's Letter to CEO's, A sense of purpose', BlackRock 2018
101. Hock, D., 'The Chaordic Organization: Out of Control and Into Order', *World Business Academy Perspectives*, vol. 9, no. 1, 1995, p. 7, https://www.ratical.org/many_worlds/ChaordicOrg.pdf
102. Ashby, *An Introduction to Cybernetics*, p. 244
103. Ashby, *An Introduction to Cybernetics*, p. 244
104. Ashby, *An Introduction to Cybernetics*, p. 268
105. Ashby, An Introduction to Cybernetics. pp. 268-269

checking its temperature 100 times a day to create 36,500 corrections a year. Ashby uses 'bits' as the transaction cost to make corrections directly or indirectly by supplementing control by acquiring a thermostat for which the cost in bits is minor. The thermostat provides a way to *amplify control indirectly*. It is through supplementing the very weak power of TV broadcast signals with external power sources that the signals become sufficiently amplified to communicate with humans.

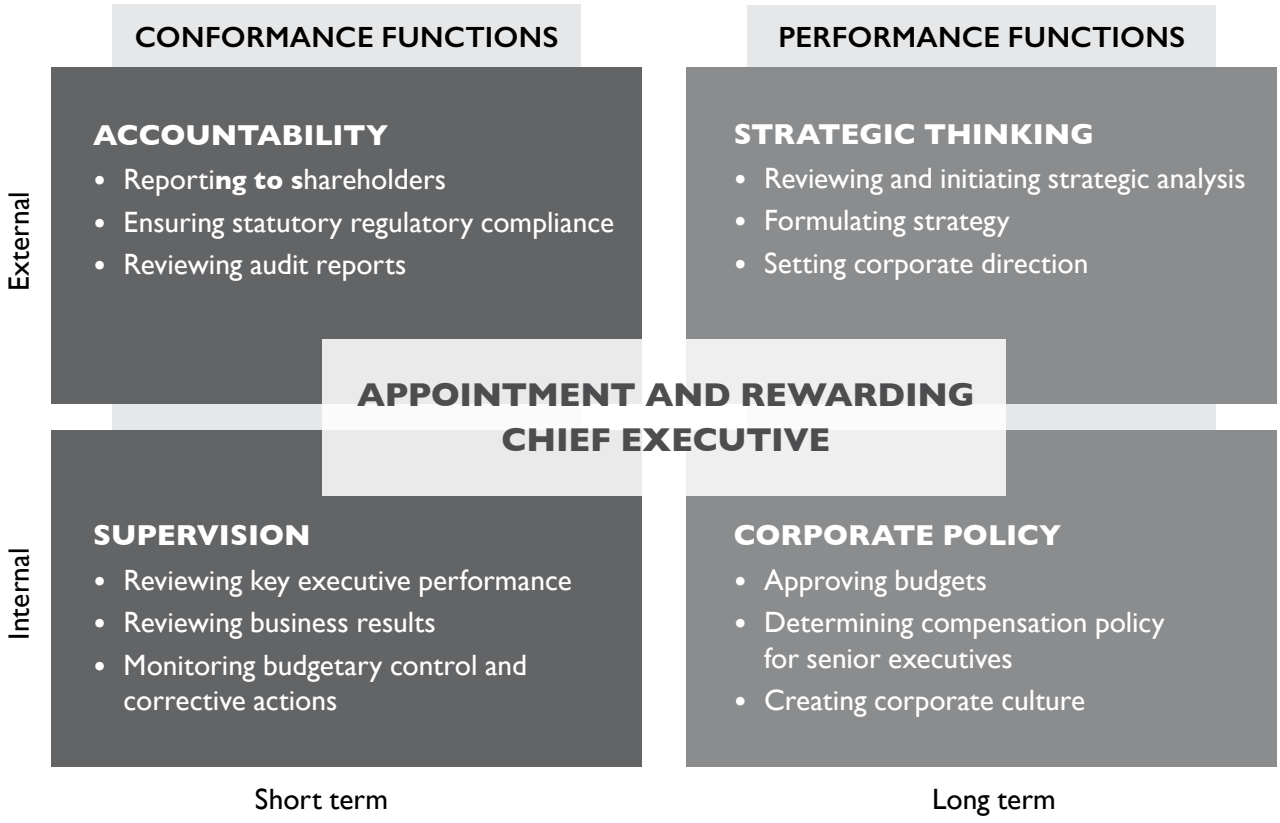
How such processes can be introduced into social organisations is considered in the following section.

DISTRIBUTED DECISION MAKING IN NETWORK ORGANISATIONS

Distributed decision making creates an important way to simplify complexity. The MCC stakeholder cooperatives provide a practical example. They show how ecological governance decomposes decision making of a single board into a variety of control centres to introduce distributed intelligence and so a much richer form of democracy.

Tricker[106] identifies the five main functions and activities of a unitary board as set out in Figure 2 .

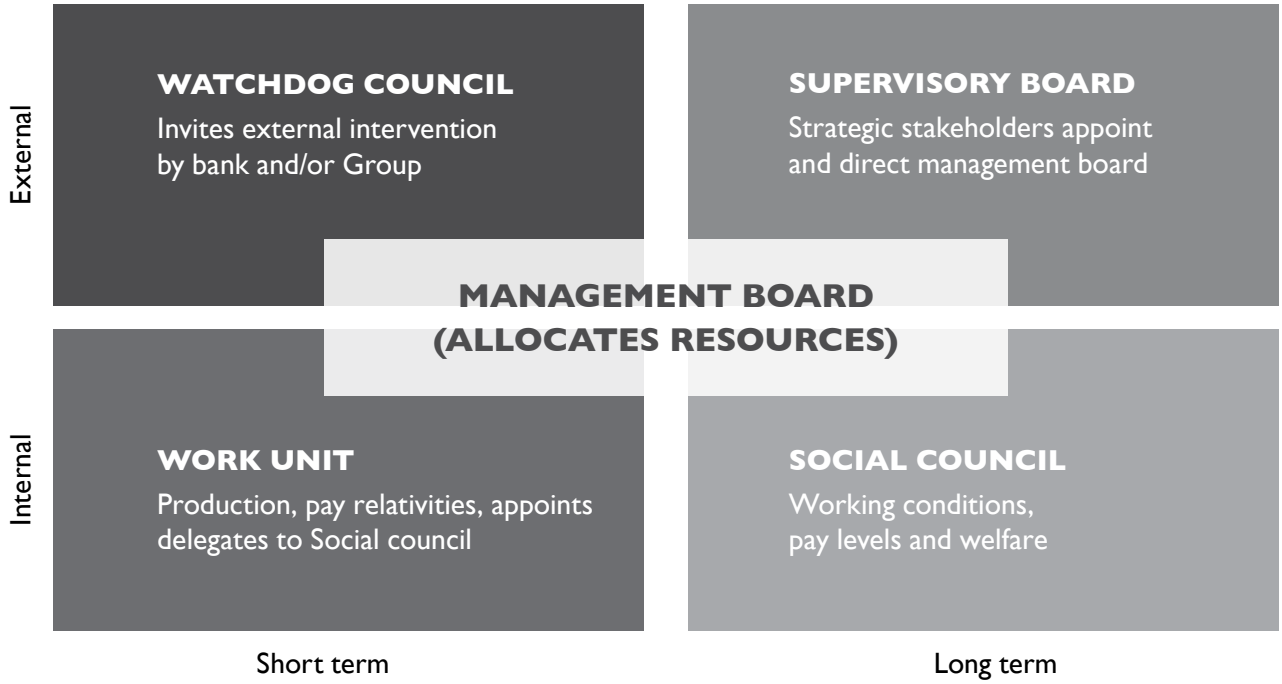
FIGURE 2:[107] Functions and activities of a unitary board



106. Tricker, *Corporate Governance: Principles, Policies and Practices*, pp. 245, 287

107. Reproduced from R.I. Tricker, *International Corporate Governance*, Simon & Schuster, Singapore, 1994, pp. 245, 287

FIGURE 3:[108] Functions and activities of Mondragón compound board



In a MCC stakeholder cooperative the five functions and activities of a unitary board are distributed to five separate decision-making centres, as shown in Figure 3. Each centre becomes elements of a 'compound board' as defined in Turnbull.[109] Figure 4 compares the workload of each of the five elements of the compound board with a single board typical of Anglophone cultures. It reveals how the workload of a unitary board is distributed over all members of the firm to create bottom-up and outside-in feedback to the traditional top-down process.

There can be many different 'work units' that make decisions on relative pay rates of their members.

These self-managing units could also be described as 'polycentric' republics or a 'holon'. They appoint delegates to the social council that is itself a compound board. In this way, individuals, work units, and the social council become part of a holarchy. The firm, its cooperative group, and the MCC each represent a self-managing entity that can be described as 'polycentric compound republics'. Alternatively, they could be described as a holarchy created by ecological governance. Each level takes on different roles along the lines cited by Mathews,[110] whose article did not mention the MCC or Tensegrity.

108. Reproduced from Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples', p. 245, based on: W.F. Whyte and K.K. Whyte, *Making Mondragón: The Growth and Dynamics of the Worker Cooperatives Complex*, Ithaca, NY, ILR Press, 1988
109. Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples', p. 41
110. Mathews, 'Holonic Organizational Architectures', p. 41

FIGURE 4:[111] Mondragón compound board compared with unitary board

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

111. Reproduced from Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples', p. 245. R.I.M. Dunbar, 'Co-evolution of neocortical size, group size and language in humans', *Behaviorial and Brain Sciences*, vol. 16, pp. 681-735, 1993

When a MCC firm grows in size to beyond manageable human neurological limits[112], it divides into two like an amoeba. One firm then becomes a supplier or customer of the other. This creates a lateral division of decision-making labour. It also contributes to creating groups of firms that share some functions like accounting and marketing through a cooperative of the cooperative group. The MCC now has a number of these cooperative groups, each with its internal system of network governance to share the functions of up to a dozen or so firms like a Keiretsu group.[113] The cooperative groups are then federated at a third level of the holarchy to create the MCC as illustrated and described in Turnbull.[114]

How the concept of holons radically simplifies and explains the complexity of the 200 firms in the MCC system is demonstrated in a 'Table 6.1, Holon typology of Mondragón'.[115] The possibility of using the architecture of nature to govern humanity to preserve both nature and humanity is articulated in Turnbull,[116,117] in a way to that could also establish: 'government of the people, by the people, for the people'.[118]

The existence of the MCC in Europe, the John Lewis Partnership in the UK, and VISA international in the US provides evidence that network governed firms with an ecological communication and control architecture can be established without any changes in the law in major jurisdictions. How the insights and concepts demonstrated in such firms could be introduced to simplify the complexity of publicly traded firms, large private firms, non-profits, and government owned firms is next considered.

OPPORTUNITIES FOR SYSTEMICALLY SIMPLIFYING ORGANISATIONAL COMPLEXITY

This section considers how elements of ecological governance could be systematically introduced to publicly traded firms, large private organisation, non-profit organisations and government bureaucracies. The incentive to do so is to improve operations by increasing the ability of organisations to reliably simplify complexity comprehensively. Another incentive is to eliminate and mitigate the systemic conflicts of interest in hierarchies. Governments have an incentive to adopt ecological governance to minimise the size, cost, and complexity that alienates voters. Government departments, corporations, and agencies could become role models[119] to ironically remove key arguments for privatisation. It would introduce 'Associational Democracy'[120] to augment and reinforce legislative democracy.

Neither economic markets nor simple hierarchies occur in nature. Nature survives and excels by using variety introduced by tensegrity to produce competition for survival. Tensegrity is both denied and discouraged in hierarchies. A condition precedent for introducing tensegrity is to separate the power to manage from the power to govern, as shown in Figure 1. This shows both a 'Management board' and a 'Board of governors'. Turnbull[121] has

112. R.I.M. Dunbar, 'Co-evolution of neocortical size, group size and language in humans', *Behaviorial and Brain Sciences*, vol. 16, pp. 681-735, 1993.
113. Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples', p. 225
114. Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples', p. 245
115. Turnbull, 'The Governance of Firms Controlled by More Than One Board: Theory Development and Examples', Table 6.1, Holon typology of Mondragón, p. 221
116. Turnbull, 'Emergence of a Global Brain: For and from World Governance'
117. Turnbull, 'Design Criteria for a Global Brain'
118. A. Lincoln, Handwritten copy of 1863 Gettysburg address prepared for Colonel Bliss, 1864, http://www.abrahamlincolnonline.org/lincoln/speeches/gettysburg.htm
119. S. Turnbull, 'Best Practice in the Governance of GBEs', pp. 99-109
120. P. Hirst, *Associational Democracy: New forms of economic and social governance*, Policy Press, Cambridge, 1994
121. Turnbull, 'Corporate Charters with Competitive Advantages'

twice introduced this arrangement in enterprises he has founded. It allowed him to negotiate exceptions from the law with the regulator because superior investor protection was introduced. It provided an example of how to introduce a systemic process for de-regulation by introducing elements of self-governance that is an intrinsic feature of ecological governance.[122]

Regulators are created to protect stakeholders. It makes political sense to make regulators accountable to KPIs set by stakeholders, as indicated in Figure 1. Governments could then determine the remuneration and tenure of its regulators subject to them meeting stakeholder KPIs. It would encourage regulators to adequately resource stakeholders to become co-regulators, as indicated in Figure 1 and described in Turnbull.[123] This would also protect responsible Ministers and the Government.

How elements of ecological governance could be introduced in various types of large complex organisations is indicated in Figure 1, which features generic illustration of ecological governance with stakeholders as co-regulators. Polycentric self-managing stakeholder organisations, as illustrated on the left-hand side of Figure 1, could be introduced by changes in the constitution and by-laws of corporate entities such as achieved by Turnbull.[124] Stakeholder forums introduce the 'requisite variety' of both communication and control channels to crosscheck augment and mentor management as much as desired by increasing the density of their networks. The detailed steps for their introduction are inspired by the Citizen Utility Boards (CUBs) introduced by Ralph Nader to reduce regulatory capture in the US[125].

Evidence of CUB efficacy is their existence decades later (details are provided in Turnbull).[126,127] The operating advantages for shareholders, directors, managers, auditors, and stakeholders are detailed in Turnbull.[128] The 'bottom–up' stakeholder associations in Figure 1, represent holons or the 'polycentric' self-governing 'republics' referred to by Ostrom[129] and Ostrom and Allen.[130] The stakeholder boards jointly establish a compound board, as shown in Figure 1 to provide political processes to manage the various conflicts of interest between investors and stakeholders and between different stakeholders. It is these conflicts that introduce tensions to create tensegrity to maintain cooperative checks and balances to avoid and mitigate tragedies of common corporate interests.

Figure 1 represents 'a new model of corporate governance' needed for Fink[131] to achieve his objective of firms benefiting all stakeholders. As revealed by the Ostroms, it is an ancient form of governance. Organisations that promote benefits for all their stakeholders become a common good.[132] In this way, global firms could become an instrument for promoting global common goods such as cleaner air, water, oceans, and healthy environments for nurturing bio-diversity to maintain humanity and the wellbeing of the planet.

122. S. Turnbull, 'The Theory and Practice of Government De-regulation', *International Finance Review: Institutional Approach to Global Corporate Governance*, vol. 9, 2008, pp. 117-139, http://ssrn.com/abstract=1008453
123. Turnbull, 'Causes and Solutions for Misconduct in the Financial Services Industry', Law and Financial Markets Review, 2019, April, https://doi.org/10.1080/17521440.2019.1602694
124. Turnbull, 'Corporate Charters with Competitive Advantages'
125. B. Givens, *Citizen Utility Boards: Because utilities bear watching*, Centre for public interest law, University of San Diego, School of Law, California, 1991
126. Turnbull, 'Causes and Solutions for Misconduct in the Financial Services Industry'
127. Turnbull, 'The Science of Governance: A Blind Spot of Risk Managers and Corporate Governance Reform'
128. S. Turnbull, 'Discovering the "Natural Laws" of Governance', *The Corporate Board*, March/April, ed. R. Ward, Vanguard Publications Inc.: Okemos, MI, 2012, http://ssrn.com/abstract=2062579
129. Ostrom, 'A Polycentric Approach for Dealing with Climate Change'
130. Ostrom and Allen, *The Political Theory of a Compound Republic: Designing the American Experiment*
131. Fink, 'Larry Fink's Letter to CEO's, *A sense of purpose*, BlackRock, 2018
132. Turnbull, 'Causes and Solutions for Misconduct in the Financial Services Industry'

The alternative was articulated by Hock[133] nine years before the 2008 global financial crisis, who noted:

> **We are experiencing a global epidemic of institutional failure that knows no bounds. We must seriously question the concepts underlying the current structures of organization, and whether they are suitable to the management of accelerating societal and environmental problems – and, even beyond that, we must seriously consider whether they are the primary source of those problems.**

The problem of avoiding the 'global epidemic of institutional failure' is becoming much more pronounced in the current century as complexity accelerates. This paper provides insights as to why this so and how they can be overcome. The solution depends upon this knowledge being shared and applied. The insights of this paper demonstrate, that it is impossible for governments, their regulators or private sector CEOs of large organisations to reliably and comprehensively regulate complexity relying solely on their current top-down systems.

The Australian Royal Commission referred to above failed to recognise this point submitted by Turnbull[134] and so failed to identify both the root causes and systemic solution to the problems they were investigating. This systemic problem of hierarchies is also being investigated by Australian Royal Commissions into: 'Aged care Quality and Safety' in 2018, and 'Violence, Abuse, Neglect and Exploitation of People with Disabilities' in 2019.[135]

The challenge for society, and especially for schools of business or government, is that their implicit assumption that command and control hierarchies represent the natural order of things is the fundamental cause of existential risks; a belief reinforced by the dominance of monotheism. This may explain why the theory and practice of designing corporate charters to introduce elements of ecological governance remains an intellectual black hole.

The authors pioneered the first MBA unit in the world that provided education on how to evaluate and design network governed organisations at Macquarie University in 2003. Elements of our course were introduced to graduate law students at the Swiss International Law School in 2015. Columbia Law Professor Katharina Pistor developed the course with Turnbull[136] being required reading with a video introduction by Turnbull.[137] The authors would welcome the opportunity to assist scholars and educational institutions in developing similar courses that could also be used to extend management education to managing global problems.

The importance of this article was highlighted by the US Business Roundtable[138] which announced on 18 August 2019 that 181 of its CEOs had committed 'to lead their companies for the benefit of all stakeholders – customers, employee, suppliers, communities and shareholders'. While the BlackRock CEO was a signatory, there is no mention of his proposal for 'a new model of corporate governance' cited by authors. CEOs committed to many stakeholders would be accountable to no one. This would undermine shareholder primacy, a feature that is preserved by the authors in their Figure 1.

133. D. Hock, *Birth of the Chaordic Age*
134. S. Turnbull, 'Causes and solutions for misconduct in the financial services industry', September 21, reference number POL.0001.2000.0003, 2018, and S. Turnbull, 'Regulating Financial Misconduct: Should the existing law be administered or enforced differently?' October 26, reference number: POL.1000.0001.0917, https://financialservices.royalcommission.gov.au/Submissions/Documents/interim-report-submissions/POL.9100.0001.0917.pdf.
135. https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/Browse_by_Topic/law/royalcommissions
136. Turnbull, *A New Way to Govern: Organisations and Society after Enron*
137. S. Turnbull, *Practices, science and art of drafting corporate charters and Bylaws*, Video posted at: https://vimeo.com/137118382/1d7e82ce27
138. https://www.businessroundtable.org/business-roundtable-redefines-the-purpose-of-a-corporation-to-promote-an-economy-that-serves-all-americans

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