Organizational Design and Collaborative Networked Organizations in a Data-Rich World: A Cybernetics Perspective

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Abstract. This paper will examine the importance of big data tools and digital technology for organizational design. Drawing on principles of cybernetics, particularly Ashby's law of requisite variety and Beer's Viable System Model (VSM), it will examine the potential implications of big data and digital developments for whether organizations need to be more centralized, decentralized or adopt networked arrangements with different level of stability and flexibility. The premise of the paper is that, for systems (such as organizations or collaborative networks) to remain viable, their internal complexity needs to reflect that of the environments in which they are based. Examples are provided from the case of the network agreement framework in Italy, which are analyzed using VSM as a theoretical framework.

Keywords: Organizational design, cybernetics, collaborative networked organizations, stability, flexibility, centralization, decentralization.

1. Introduction

This paper examines the importance of big data tools and digital technology for contemporary organizational design. It sets out to understand whether, in today's data-rich world, organizations need to be more centralized, decentralized or adopt networked arrangements [1]. While accepting the importance of reference models for analyzing and developing 'Collaborative Networks' [2], the paper provides fresh theoretical insights by drawing on principles of cybernetics, particularly Ashby's law of requisite variety and Beer's Viable System Model (VSM). As Kandjiani and Bernus [3,4,5] have noted, given the trans-disciplinary nature of the cybernetics field, such ideas provide a potential way of unifying disparate theoretic approaches to the literature on networks. In aiming to contribute to the valuable stream of research Kandjiani and Bernus define as 'Cybernetics of Collaborative Networks', this paper focuses on 'complexity management' in network design and the need for organizational structures to exhibit the 'requisite variety' presented by their environments. Indeed, for many organizations, it is suggested, it is only by forming network arrangements that they can maintain their viability in an increasingly complex, (digital) data-driven world. To maintain viability and deal with this complexity, such networks need to exhibit a range of design features, as described by VSM. The paper seeks to validate these ideas by reference to case examples using the Italian ‘Network Agreement Framework’, which deal with a series of factors concerning the design of collaborations.

The paper is organized as follows. Section 2 discusses the rise of network structures in recent years and explains why these are closely linked to developments in digital technology and the evolution of big data. Section 3 then sets out the main theoretical framework for the paper, drawing in particular on work in cybernetics by Ross Ashby and Stafford Beer. Section 4 then describes and analyses a number of case examples of formal network agreements (in Italy), before providing a summary and conclusions in Section 5.

2. Organizations and Collaborative Networked Structures in the Digital, Data-Rich World

In one way, the modern world is a massive machine for generating, sharing and consuming data, made possible by the growth of digital technologies. The implications stretch beyond the information world itself. For Brynjolfsson and McAffee [6], we are now living through a *Second Machine Age,* in which technology is focused on the creation and manipulation of data. In contrast to the first machine age, where steam-powered machines augmented or replaced human muscle, today’s technology augments or replaces human *brains*. This also reflects what Mayer-Schönberger and Cukier [7] call ‘datafication’ – the transformation of facts about the world into a quantified format so they can be tabulated and analyzed.

Taken together, these developments have provided the impetus behind ‘big data’ techniques and technologies. What differentiates these from other forms of data manipulation is captured by Laney’s [8] notion of ‘volume, variety and velocity’. First, we can capture, store, communicate and manipulate data at a *volume* that was not possible in days gone by. Secondly, the *variety* of data – from sensors, databases, websites, etc – has also expanded. Thirdly, because there is simply more digital technology out there to capture and share data at ever-faster transfer rates, the *velocity* of data creation and communication has also increased.

A further factor about these developments is the *repurposing* of data collected for other reasons (i.e., not readymade datasets). As Mayer-Schönberger and Cukier posit [7], big data reflects ‘the ability to harness information in novel ways to produce insights or goods of significant value’ (p. 2). As Marr [9] notes, because our actions increasingly leave a digital trace, we can use that data ‘to become smarter’ (p. 9).

We now turn to the *organizational* implications of the above and their importance to the collaboration agenda. As Yoo [10], observes, among their many facets, digital artefacts are also ‘associable’ – that is, they can be linked with other actors, artefacts and places. According to Yoo *et al.* [11], digitized products thus engender a new set of ‘organizing logics’ – arrangements that enterprises need to adopt given a firm’s position in its environment and relative to customers and other players. This, Yoo *et* *al.* [11] say, reflects the ‘layered modular architecture’ of digital products. There are four layers involved here: (1) the *physical machinery* of devices themselves, (2) the *network capability* that supports the transmission of data to and from them, (3) the *services* available on them (such as the ability to create, access and manipulate content) and (4) the *content* itself (texts, images, videos, and other data).

Whereas for traditional products, whose dominant production logic was the vertically integrated hierarchy, a modular architecture leads instead to *vertical disintegration.* IT plays an additional role here, helping address the communication and coordination requirements of the inter-firm relationships that result [12]. With digital products and services, a diverse range of actors and organizations may be brought into design and production [13]. This is the case in the automotive industry, where digitization has turned automobiles into computing platforms on which outside firms can develop and supply new devices, services and content [14]. The net result is an erosion of industry boundaries and further impetus towards networked organizations. For Castells [15,16], such examples are emblematic of the contemporary ‘network society’, in which a range of social, technological and economic transformations come together to produce a new, global structure.

3. The Design of Organizational Structures in a Cybernetics Perspective: Requisite Level of Decentralization and Flexibility

The explosion of IT power bound up with big data is a seeming source of complexity in the world. Quite simply, there are more facts – and insights derived from them – with which to contend. There are also new (value-adding) services, organizations and even industries based upon these. While technology disrupts, however, it can also be used to help cope with (or ‘attenuate’) complexity. Networked IT, as Castells shows, enables forms of collaborative networked organisation that offer the sort of agility and flexibility hierarchically integrated businesses struggle to achieve [17]. It can also be used to capture and analyse intelligence about the environment (markets, customers, competitors) to support better decision-making about strategy and tactics. To understand this at a deeper level we can turn to ideas from the cybernetics literature.

For cyberneticists such as Ashby [18], complexity can be understood in terms of the ‘variety’ exhibited by a system. Variety here is the number of distinguishable states an entity (such as an organisation) can assume. Where a system can match the disturbances to its environment’s states, it is said to have ‘requisite variety’; that is, it can change its own internal states to respond to the world beyond [19].

The notion that ‘only variety absorbs variety’ is at the heart of work by Beer [20,21] in his development of the Viable System Model (VSM). The VSM identifies the functional requirements of an organization if it is to have the capacity for self-regulation. Five component subsystems are critical to this (see Figure 1): System 1 – the *operations* that produce the organization’s key outputs (its products or services); System 2 – *coordination*, which enables operational units to work together without clashes or oscillations; System 3 *delivery management* (including 3*, monitoring), which distributes resources between operations and supports overall cohesion; System

4 – *development management* (such as marketing, training and R&D), which prepares the organization for the future); and System 5 – policy and governance that sets overall direction and ensures a balance between operations and development.

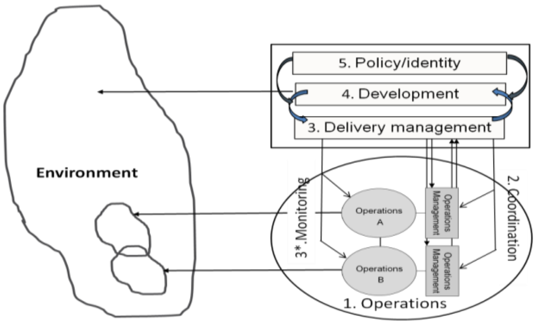

Fig. 1 - Beer's Viable System Model

The fractal nature of these functions (that they should all exist at each level of recursion and exhibit requisite variety in so doing) is crucial to the viability of the whole system. The five subsystems described also need the support of suitable communications channels (with the capacity to deal with the volume, variety and velocity of information flowing through them). Taken together, this provides each level with the capacity to self-regulate its actions and thus match the complexity of the environment [22,23]. It is through the principles described by VSM that collaborative networks are able to balance stability and change despite being in a state of seeming 'anarchy' – that is, there is no overall leader 'calling the shots'. This stands in contrast to hierarchical structures, which, in directing operations 'from the top', frequently rob lower levels of the variety they need to respond to events and disturbances. The challenge for organizations thereby becomes one of designing enterprises and inter-firm networks that confirm to these principles and, in so doing, balance the need for centralization and decentralization. Returning to Castells [15], we can see that, where modern digital technology supports such viable system designs, the resultant organizations and networks can take on more complex and dynamic forms, thus matching the variety of the wider environment. Such technologies not only help to support the articulation of new business forms; they also allow for better intelligence gathering about the environment, down to the details of customer habits and buying behavior.

We will now turn to the case of network framework agreements in Italy.

4. The Case of the Network Agreement Framework in Italy

At the beginning of the current decade, the Italian government established an innovative legal framework to formalize strategic alliances among business entities. This framework has been recognized by the European Commission as one of the best practices in this area and was included in the 'Innovation and Competence' chapter of the revised version of the Small Business Act in 2011 [24]. The contract allows two or more firms to develop and formalize collaborative strategies without the bureaucratic rigidity of alternative forms of aggregation (i.e. consortia or merger), which are then registered in the Italian Public Register of Business Entities [25]. After seven years of implementation, as at 3 March 2017, 3.479 contracts have been formalized, involving 17.664 business entities.

According to the legal framework defined, the contract [26] must explicitly indicate some mandatory collaborative arrangements regarding (law n. 122/2010): i) network strategic objectives; ii) network action plan; iii) network performance measurement criteria (to assess the progress toward strategic goals achievement); and iv) network governance model (to manage collaborative activities). Framing this regulatory discipline using the cybernetic perspective above, these conditions reflect the fundamental features of organizational network design. Consequently, the Italian network contract framework offers important opportunities for analyzing the issue of organizational network design to meet the challenges of digital transformation.

Each of the contractual elements listed above can thus be related to VSM components. First, the strategic goal-setting creates a connection between the system in focus (i.e. the networked organizations) and the external environment, in terms of the business entities involved and the objectives they (collectively) seek to achieve. In VSM terms, this reflects the 'policy/identity' (sub-system 5) of the network (the reason for the collaboration) and its 'development' activities (the sub-system 4 function that supports planning). The network action plan provides the organizational steps for the articulation of collaborative tasks and can be framed under 'delivery management' (sub-system 3), where the network performance measures become the fundamental 'monitoring' tools (supported also by sub-system 3* audits). The governance model, finally, defines the characteristics of leadership and responsibility to guide the actors' operational integration. These activities can be attributable to the 'coordination' function (sub-system 2). The operations carried out by the individual partners (sub-system 1) will then performed as part of the network structure, supported by the previous mentioned sub-systems, with the specific design defining the level of centralization/decentralization. Taken together, the approach taken overall will determine the stability/flexibility of the networked system.

To validate these assumptions, the authors explored the official records of the Network Register and selected network contracts whose strategic objectives included some 'digital' issues, such as web technologies, big data, digital transformation and industry 4.0. We found eight agreements, with partners varying from 3 to 10, and located in most Italian macro-regions (North, Centre North and Centre-South). Based on partner specializations and strategic objectives, we classified these into four possible strategic arrangements, identifying an increasing level of complexity based on the concept of the 'business model'[1] [27]. The complexity, here, depends on whether the digital services/technologies mentioned are intended to integrate: i) the value proposition of partners as service suppliers for marketing processes; ii) the value proposition of partners as service suppliers for production processes; iii) the marketing process of the partners' business model as goods producers; and iv) the

[1] Business model is considered as the organizational and financial architecture based on processes directed to define three main components: 1. Value proposition; 2. Value creation; 3. Value capture (Richardson J.: The business model: an integrative framework for strategy execution. Strategic Change, vol. 17, n. 5-6, 2008, pp. 133-144).

production and supply-chain processes of the partners' business model as goods producers.

At the same time the network action plan, performance measurement and governance model were analysed according to different classification criteria, identifying four arrangements of VSM sub-systems design, characterised by an increasing level of network centralization and stability. At the first level it is possible to find network structures whose collaboration is designed for information exchange and sharing, with no specific performance measures and managed by a representative board of directors with low/undefined frequency of meeting. At the opposite level we found a case of a networked structure committed to performing a joint plan of tangible/intangible investments, with specifically defined performance measures and appointing specialized board/experts in charge of the network governance – thus presenting a higher level of centralization and stability.

Table 1. Analysis criteria according to VSM sub-systems

Network contract requirements	**Network strategic objectives**	**Network action plan**	**Network performance measurement**	**Network governance model**
VSM components	**Policy and development (sub-system4&5)**	**Delivery management (sub-system 3)**	**Monitoring (sub-system 3*)**	**Coordination (sub-system 2)**
Increasing level of digital complexity (sub-system 4&5) and network centralization stability (sub-systems 3, 3* and 2)	1. Supplying of digital services for marketing processes 2. Supplying of digital services for production processes 3. Integration of digital technologies in marketing processes 4. Integration of digital technology in production processes	1. Information exchange and sharing 2. Process integration and synergies development 3. Joint research on specific projects 4. Tangible and intangible joint investments	1. Not specified 2. Generic measures 3. Macro-process specific measures 4. Projects specific measures	1. Representative with undefined/low frequency 2. Representative with high frequency 3. Specialized /expert with undefined/low frequency 4. Specialized/expert with high frequency

Table 1 synthesizes the links between formal requirements and VSM components, and indicates the criteria adopted for analysing the network contracts. Applying these criteria to the selected contracts and differentiating them into two groups characterised by different levels of digital complexity (Group 1: value proposition digital integration, and Group 2: business model digital integration), the figure below (Figure 2) graphically reports the scores related to the VSM components and the average level reached by the two groups on each sub-system.

Conversely, the second group includes a contract (Network 7) with a more loosely structered design in terms of management, monitoring and govenance, despite having an ambitious goal in terms of digital integration of the business model. Because this could be related to the limited number of partners (n. 3 partners), it would be important to assess the impact of this less thought-out design on the effective implementation of collaborative operations.

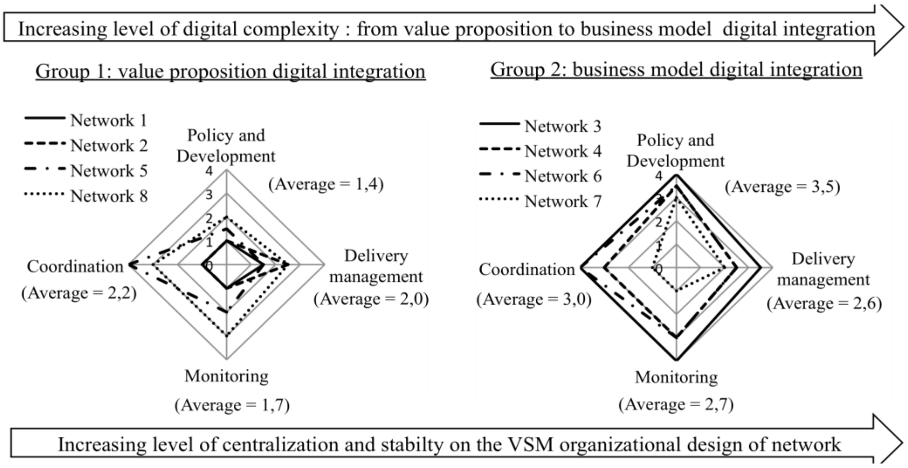

Fig. 2 – Features of organizational design for collaborative networked structures

5. Summary and Conclusions

This paper has argued that, in a data-rich world enabled by digital technology, the emergence of networked organizations is a natural consequence of the need to manage the complexity presented by the environment. In doing this, enterprises face a range of design choices, particularly in terms of centralization and decentralization. Getting this right demands a deeper theoretical understanding of how organizations and networks can be designed and managed to handle that complexity (or 'variety'). The paper has argued, using case examples from Italian Network Agreements, that cybernetics theories, particularly the Viable System Model, provides powerful insights in doing this and offers value both to researchers and practitioners.

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