PANDEMICS AND INTERDEPENDENCE

If there is one thing that the COVID-19 pandemic has taught us, it is that we live in an interdependent world. The pandemic has brought into stark relief three forms of interdependence. First, we see more clearly than ever the interrelationships between human and non-human networks, with human invasion of animal habitats and people’s connectivity via global transportation systems creating the perfect conditions for pandemics. Second, the chains of interdependence linking human and non-human networks are both complex and tightly coupled, such that the employment of an individual or the performance of a company on one continent are not independent of the wildlife that people on the other side of the world come in contact with. Third, we have learned that the response to pandemics hinges on the management of interdependent tasks performed by organizations, industries, nation-states and international institutions, and the resources each deploy over time toward the execution of those tasks; lacking a coordinated response to these interdependencies, global supply chains are disrupted, delaying the production and distribution of vital supplies to communities that need them, and slowing – sometimes fatally – how businesses large and small adapt to shifting market demand and the resources required to meet it.

Although interdependence has long been an object of inquiry in both organizational theory – for example, with research on high-reliability organizations (e.g., Perrow, 1984) – and strategy – with work on firms as ecosystems of interdependent choices (e.g., Siggelkow, 2011) – the exceptional scope and intricacy of social and economic reverberations from pandemics recast interdependence as a newly central construct in management studies. Management scholars must, therefore, re-assess the assumptions, theories, methods they draw from to address the unique challenges presented by ubiquitous and
multifaceted interdependence in the life of organizations. This is where the network perspective is poised to offer uniquely valuable contributions.

**SOCIAL NETWORK THEORY AND ANALYSIS AS A SCIENCE OF INTERDEPENDENCE**

While organizational studies tend to assume independence of observations or remove interdependence statistically, social network scholars view the structure of interdependence as the primary focus of their research: from a network perspective, interdependence is the essential lens for understanding organizational behaviour.

A network is seen as a system of interdependent units wherein the behaviour and outcomes of an individual node – be it a person, an organization, an industry or even a nation-state – depend on the structural pattern of relationships between that node and other nodes. For example, the probability of an individual being promoted in an organization depends not just on her competence and performance, but also on her ties to high-rank individuals in the organization, as well as the ties that her peers have with influential organization members. To pursue their theoretical interest in interdependence, network scholars develop and adopt special statistical approaches – such as, stochastic actor-oriented models and exponential random graph models – to model the non-independence of network data, both statically and dynamically. In so doing, network scholarship has produced remarkable insights on individual and collective organizational phenomena and their evolution (for reviews, see Borgatti and Foster, 2003; Kilduff and Brass, 2010).

Two forms of interdependence evidenced by the COVID-19 pandemic have, however, taken a backseat in social network research: first, the interdependence of networks across classes of nodes, known as bimodal, two-mode, or *k*-partite networks (for example, networks between people and the ecosystems they interact with, the organizations they work for, and the transportation and trade networks that connect the communities they live in); second, the patterns of interaction between nodes over time, or *network motifs*, which represents the temporal paths of interdependence in a network. Scholarly understanding of these two forms of interdependence stands to greatly advance management studies.

**TWO FORMS OF NETWORK INTERDEPENDENCE FOR FUTURE MANAGEMENT RESEARCH**

**K-partite Networks and the Pluralism of Interdependence**

Most social network research in management is concerned with one-mode networks, defined as networks that connect only one type of node, such as advice-giving relationships between employees of an organization or strategic alliances between firms. Many networks relevant to management research, however, have a two-mode (or even a multi-mode) nature. A two-mode network – also called a bipartite, two-partite or affiliation network – is one that connects two varieties of nodes. A network of corporate directors and the companies they are affiliated with is an example, as is a network of venture capital firms and the entrepreneurs they fund. Two-mode and multi-node (*k*-partite) networks
are also clearly in operation in a pandemic, with relationships connecting human, animal, biological and technological networks creating interdependencies across multiple classes of nodes.

K-partite networks also exist within a single organization and their analysis can yield valuable insight about its functioning. A recent study of a public organization provides a case in point (Ujwary-Gil, 2017). The study considers both human nodes – the members of the organization – and the non-human nodes represented by the knowledge and resources that these employees have or require to carry out assigned tasks. The resulting two-mode network linking people to knowledge, resources and tasks reveals not only who is prominent in the organization by virtue of having many connections – the conventional analytical focus of one-mode network studies – but also for whom this network prominence comes with an overload of knowledge, resources and tasks, which threatens an employee’s productivity and effectiveness – an outcome that the typical study of one-mode advice networks could not uncover.

Moving beyond the study of interdependence in one-mode networks to consider more complex forms of interdependence in k-partite networks can thus productively shift the analytical focus of organizational network research. One of its defining characteristics over the past few decades, for example, has been the disproportionate attention devoted to bridging structural holes as a desirable network strategy for both individuals and organizations. Access to and control over non-redundant information are the proposed mechanisms for the advantages of occupying such positions in networks. Yet, pandemics and studies like Ujwary-Gil’s demonstrate that building redundancies in the network structures that social actors rely on to execute tasks – what we might call network buffering – may be as important as network bridging, because it builds robustness to manage complex interdependencies across networks and adapt to disruptions to established intra- and inter-organizational arrangements.

This insight opens intriguing research questions ripe for theoretical development. For example: Under what conditions is network bridging versus network buffering the key to a coordinated execution of interdependent tasks performed by organizations, nation-states and international institutions? When do redundant connections across networks facilitate adaptive performance by lowering vulnerability to the failure of nodes in one network? When is the bridging of structural holes across networks an engine of innovation or a source of systemic risk instead? And how can organizations design interventions to elicit two-mode ties – e.g., between individuals and organizational units – in order to manage cross-network interdependencies?

Network Motifs and the Temporal Structure of Interdependence

All networks – including not only social networks, but also biological, technological (e.g., computer and transportation networks) and economic networks (e.g., trade transactions) – can be represented as graphs, which include a variety of subgraphs. One important local property of networks are so-called network motifs, defined as recurrent and statistically significant subgraphs that repeat themselves in a network or even between multiple networks comprising timestamped links between the nodes.
Motifs are important because they can reflect how particular functions are achieved efficiently in a network. Moving beyond classic organizational theory – such as, Thompson’s (1967) renowned distinction between pooled, sequential and reciprocal types of interdependence – network motifs identify emergent, varied and complex temporal patterns of interaction that reflect how actors in a network perform their roles. Think about how people in an organization interact to search for and transfer knowledge they require to perform assigned tasks. A motif analysis can surface, for example, how much hierarchical interdependence affects relational behaviour in an organization (e.g., with people moving knowledge up and down vertical paths of authority rather than alternating over time between horizontal knowledge exchanges with peers and vertical interactions with superiors and subordinates).

The study of network motifs can identify patterns of interdependence that slow or accelerate knowledge diffusion and task execution, as well as identify opportunities for aligning the formal design of organizations with the functions they are intended to serve. For this reason, motifs are garnering increasing attention as a useful construct to uncover structural design principles of complex networks in organizations.

Advancing a research agenda on the temporal structure of interdependence within and between organizations requires theorizing what constitutes a meaningful motif by answering questions such as: What are the theoretical dimensions for a classification of network motifs? How can network scholars classify network motifs based on a theory of the mechanisms – e.g., reciprocity, transitivity, horizontal flows, vertical flows, circular flows, etc. – responsible for their effects on task execution, knowledge transfer, coordination, innovation, and any number of organizational phenomena? Making headway toward such a theory of temporal patterns of interdependence would open fruitful possibilities for management research.

OVERCOMING METHODOLOGICAL BOUNDARIES

Despite their ubiquity of k-partite networks and network motifs within and between organizations, and the analytical possibilities that these patterns of interdependence open for inquiry, such network structures still feature rarely in management studies. In addition to the undeniable challenge of theorizing k-partite networks and motifs, other culprits for this void are methodological. The statistical modelling of these network configurations remains impractical for most researchers, requiring specialized training and constant updating. And although network motifs may provide deep insight into the network’s functional abilities, their detection is computationally challenging. Likewise, few specialized techniques for the bimodal analysis of two-mode networks have been developed (Borgatti, 2012).

The analytical repertoire has been expanding, however, with researchers developing new statistical approaches – such as, the relational events framework for temporal network data (Butts, 2008) – or extending to two-mode networks tools used to analyse one-mode networks (Everett, 2016; Latapy et al., 2008). The data required to measure two-mode networks and network motifs are also increasingly within reach, with large data sets on email communication, global supply chains, and social media platforms as
examples of the new possibilities opened by big data. When the methodological sophistication required by these complex forms of interdependence increases beyond the reach of most management scholars, collaborations with mathematical sociologists and other technical specialists provide a way forward.

Expanding the theoretical and analytical focus of organizational network research to include pluralistic patterns of interdependence over time is vital. The social and economic reverberations of the COVID-19 pandemic, and the environmental disruptions that underlie it, force management scholars beyond their comfort zone and into the investigation of nuanced forms of interdependence that can invigorate the relevance of management studies in a changing world.

REFERENCES

Borgatti, S. P. (2012). ‘Social network analysis, two-mode concepts’. In Meyers, R. (Ed.), Computational Complexity. New York: Springer, 8279–91.

Borgatti, S. P. and Foster, P. C. (2003). ‘The network paradigm in organizational research: A review and typology’. Journal of Management, 29, 991–1013.

Butts, C. T. (2008). ‘A relational event framework for social action’. Sociological Methodology, 38, 155–200.

Everett, M. G. (2016). ‘Centrality and the dual-projection approach for two-mode social network data’. Methodological Innovations, 9, 1–8.

Kilduff, M. and Brass, D. J. (2010). ‘Organizational social network research: Core ideas and key debates’. Academy of Management Annals, 4, 317–57.

Latapy, M., Magnien, C. and Del Vecchio, N. (2008). ‘Basic notions for the analysis of large two-mode networks’. Social Networks, 30, 31–48.

Paranjape, A., Benson, A. R. and Leskovec, J. (2017). ‘Motifs in temporal networks’. In Proceedings of the Tenth ACM International Conference on Web Search and Data Mining, Association for Computing Machinery, New York, NY, 2 February, 601–10.

Perrow, C. (1984). Normal Accidents: Living with High-Risk Technologies. New York: Basic Books.

Siggelkow, N. (2011). ‘Firms as systems of interdependent choices’. Journal of Management Studies, 48, 1126–40.

Thompson, J. D. (1967). Organizations in Action. New York: McGraw-Hill.

Ujwary-Gil, A. (2017). ‘Intra-organizational two-mode networks analysis of a public organization’. Economics and Sociology, 10, 192–205.