



Edited by
Anna Moretti
Lisa Balzarin

New Perspectives in Network Studies

A Multidisciplinary Approach

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Introduction

Lisa Balzarin and Anna Moretti

1 Networks and Organizations

Networks are pervasive in social and economic life, and the concept itself has been used to describe a plethora of different phenomena. Kilduff and Tsai (2003, p. 13) reconstruct the origins of social networks studies, highlighting how network ideas were imported by social sciences from three main sources that originated in the first decades of the twentieth century. The first can be traced back to German researchers (among which Lewin and Heider) that, influenced by physicians working on field theory, started what now we identify with the field of network research on cognition and interpersonal influence, with a mainly descriptive nature. The second source is rooted into the mathematical approach to social interaction that USA researchers (e.g. Cartwright and Harary, and

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then with the work of Harrison White) developed working with graph theory, moving Lewin's work from description to analysis. The third main source originates into organizational researchers based in the Harvard Business School that used sociograms to represent the structure of social interactions in their anthropological investigations of factory life.

These multidisciplinary origins of the social network approach developed in the following decades and gave birth to one of the most prolific and transversal areas of research for its application to many fields as different as physics, biology, linguistics, anthropology, sociology, economics and management. The network approach, in fact, "allows researchers to capture interactions of any individual unit within the larger field of activity to which the unit belongs" (Kilduff & Tsai, 2003, p. 13). In this view, the network perspective offers a distinctive focus on social interactions that allows capturing the complexity of organizations and their micro, meso and macro social systems necessary to tackle some fundamental questions for management and organization scholars.

Network studies developed along different lines of investigation, encompassing a great number of topics at different levels of analysis, and thus making it somehow difficult to see the coherence within the diversity (Kilduff & Brass, 2010). Studies developed along the line of research that used network analysis as an "orientation towards the social world that inheres in a particular set of methods" (Scott, 2000, p. 37) and in which the concept of network is used to describe configurations and structures. This field of research mainly builds on theories borrowed from other disciplines, such as graph theory from mathematics and balance theory and social comparison theory from social psychology (Kilduff & Tsai, 2003), and uses concepts and measures (degree of connectedness, graph hierarchy, graph efficiency, etc., on the one side, and cliques, Simmelian ties, homophily, etc., on the other) to describe interactions between connected units.

Alongside this line of investigations there are home-grown theories on social networks such as the strength of weak ties (Granovetter, 1973, 1983), structural holes (Ronald S. Burt, 1992, 1995), embeddedness (Granovetter, 1985; Uzzi, 1996), and the co-evolution of network

approaches and organization theories (e.g. resource dependence, contingency theory, population ecology, transaction cost economics and knowledge-based view of the firm). Within this area of research, scholars contribute to build a critical synthesis of network approaches and management studies answering to research questions traditionally belonging to several areas of research (organization, strategy, accounting, finance, law, etc.).

Indeed, networks have also been at the centre of the organizational debate developed by scholars connecting networks and organization theory, and specifically those exploring the emergence of new organizational forms (Podolny & Page, 1998). This line of investigation, after almost two decades of debate, is now aligned on the acknowledgement of networks as a distinct form of governance (Powell, 1990), with its distinctive rules and functioning mechanisms. Network organizations are those meta-organizations that are constituted by autonomous entities working together for a common goal, based both on formal and informal mechanisms of coordination (Moretti, 2017). Scholars contributing to this field of research identify network organizations as other from markets and hierarchies, and claim the necessity to develop its own theory—especially in recent times with the emergence of the ecosystems field of research (Jacobides et al., 2016; Shipilov & Gawer, 2020).

The network concept and its multi-faceted nature have the advantage to bring together different analytical approaches (quantitative, qualitative and graphical analysis) and to help scholars use this flexibility for both empirical exploration and theoretical research on organizational settings (Ibarra et al., 2005). The rich multidisciplinary approach that characterized the birth and life of network studies suggests that they have the potential to complement management studies in the analysis of an increasingly complex world, where challenges as important as the digital transformation, the sustainable development, and the international tensions in the political, social, health and safety domains are changing organizations and institutions.

2 New Perspectives on Network Studies: Performance and Agency

The present book is the result of a call for chapters aimed at collecting contributions from scholars belonging to the NOIS (Network Organization Innovation and Strategy) research centre to bring together their many different disciplinary approaches to the study of networks and organizations. The editors, after collecting the first proposals, organized three different workshops aimed at discussing the potential contributions of the multidisciplinary approach. What emerged was that all the authors were proposing, from their specific research area, a different view on two main topics at the centre of the recent debate of network studies: performance and agency.

As acknowledged by organizational scholars, “networks within which people and groups are embedded have important consequences for the success and failure of their [individual or collective] projects” (Ibarra et al., 2005, p. 359), and these outcomes cannot be fully understood and explained without the appreciation of individuals’ agency aimed at modifying the framework of benefits and constraints represented by network structures (Kilduff & Brass, 2010)—thus shifting from a static to a dynamic perspective (Ahuja et al., 2012; Tasselli & Kilduff, 2021; Tasselli et al., 2015). Nevertheless, still many grey areas characterize the research on network outcomes that we can organize in three different categories, highly interrelated: definition, levels of analysis and network trajectories (Kilduff & Tsai, 2003).

Network outcomes do not rely on a clear definitional ground, and the research has been developed along two main tensions: performance versus effectiveness, and outcomes versus coordination. The first tension distinguishes the network performance—intended as the measure of collective outcomes (Provan & Sydow, 2008), from the network effectiveness—namely the network’s ability to reach its goals (Provan & Milward, 1995). The wide range of the types of outcomes analysed encompasses, among the others, from life expectancy (Berkman & Syme, 1979) to work performance (Mehra et al., 2001), promotions (Ronald S. Burt, 1992), firms’ innovation (Ahuja, 2000) and effectiveness of public-sector networks (Provan & Milward, 2001). The second tension is

more ontological in its nature and refers to the network as a distinct form of governance on the bases of its reliance on social mechanisms of interaction and coordination (Powell, 1990). From this starting point, network performance can be defined on two different levels: its ability to get specific outcomes (referring to the first tension) and its ability to sustain coordination—in terms of fostering trust and communication between network members, and to inhibit opportunism (Moretti & Zirpoli, 2016; Schrank & Whitford, 2011). To this second network conceptualization refers the well-explored debate between the bright and the dark side of networks (Anderson & Jap, 2005; Bizzi, 2013; Oliveira & Lumineau, 2019; Soda & Usai, 1999).

Network performance suffers from some definitional confusion also because of the grey area regarding the different levels of analysis: network outcomes have been analysed as both the sum of all individual members' performance/effectiveness and as the collective result that could not be achieved by the members on their own (thus accounting for complementarities and synergies). Along the two tensions presented above, this articulation on different levels of analysis increases the definitional complexity, posing the question about the differences between (the sum of) network members' performance and performance at the whole network level—for example, network functioning (Turrini et al., 2010)—and about the distinction between individual versus whole-network goals (Sydow & Windeler, 1998).

The focus on (individual and collective) goals, and the interpretation of the network performance as its effectiveness in reaching such goals, poses the question about distinguishing how we define performance of serendipitous versus goal-directed networks (Kilduff & Tsai, 2003). As acknowledged by network scholars, in fact, networks can start and evolve both by serendipitous encounters between members and by planned processes of network building by internal or external network orchestrators. In the two cases, definition and identification of network goals will imply very different levels of consciousness, formalization and sharing between network members, increasing the complexity of defining network successful or unsuccessful outcomes.

The topic of network performance has been already connected to agency in networks by the acknowledgement of the role of individuals' strategies in modifying networks benefits and constraints in reaching

network members' own goals (Ronald S. Burt et al., 2013; Tasselli & Kilduff, 2021). In particular, a well-established criticism to network research is the lack of an adequate focus on agency (Gulati & Srivastava, 2014; Kilduff & Brass, 2010; Tasselli & Kilduff, 2021): "Network analysis all too often denies in practice the crucial notion that social structure, culture, and human agency presuppose one another" (Emirbayer & Goodwin, 1994, p. 1413). The hegemony of network structure to explain network dynamics penalizes the explanatory power of network research that, not surprisingly, is often claimed to have a methodological valence more than a theoretical one. Accounting for agency as a determinant of how networks change over time may turn the tables and provide a more realistic and complete understanding of network evolution.

One of the factors that can increase the resistance in introducing agency as part of the explanation of network dynamics is that, as a concept, agency is difficult to bound because of its multi-faceted nature. Recently, in their review on network agency in interpersonal network studies, Tasselli and Kilduff (2021) classify the existent conceptualizations of agency in four categories: (i) the interests that individuals manifest in exploiting the opportunities that the network—and how it is structured—provides, (ii) the embeddedness of the individuals in the network, (iii) the microfoundations and (iv) structuration. Despite the variety of definitions may create confusion about what agency is, it is exactly the eclectic nature of agency that can enrich our understandings of how networks change over time.

3 New Perspectives on Network Studies: The Structure of the Book

The book opens with a literature review on networks and organizations by Moretti, Piccione and Tolotti. The chapter describes how network studies have evolved in the last two decades and reveals the potentiality of understanding networks applying several theoretical and empirical perspectives.

Employing alternative perspectives is exactly what characterizes the other chapters of the book that elaborate on the notion of network

performance and agency drawing from different streams of research to contribute to the understanding of networks. The first four chapters take into account some specific aspects of agency—the way in which agents decide to represent themselves as a network and behave within the network in which they participate—to resonate on network performance and its many-sidedness. More specifically, Mogno and Nuccio's contribution elaborates on how the interaction of non-human agents—platforms and works of art—and human agency affects network performance. The chapter reflects on how the distinctive characteristics of the different types of agency may influence value creation as an aspect of the performance of a network. Chapter 4, by Chiara Saccon, describes how the difficulties in defining network performance are reflected also in networks' evaluation and communication activities, from an accounting perspective. The contribution describes how the practice of network financial reporting, and in particular the perspective of external stakeholders, can contribute to the development of network performance theories, suggesting future avenues of research on how different evaluation and communication practices can influence the space of network members' agentic behaviours. Cavara and Zirpoli's chapter brings to the front the fact that, in networks, agency may manifest in the form of unethical behaviours, and stresses the relevance of considering the ethical dimension when evaluating network performance. The study identifies future avenues of research to integrate the ethical lens in network studies. Maggistro and Pesenti's study focuses on individual agency, considering that the individuals' features and preferences affect individuals' behaviour in networks and result in different network performance. This research, which tackles the issue from the mean-filed approach, allows to reflect on the self-reinforcing mechanisms that govern networks and make their performance be—or not be—the same over time.

The last two chapters of the book assume that the network performance depends on the participation of agents, and, for this reason, they delve into the mechanisms of agency when it is embedded in a network. Balzarin's chapter works on the fact that the performance of a network, as governance, depends on the daily realization of the network in the realm of practice and adopts the Routine Dynamics perspective to shed light on the dynamics of agency that occur during the recurrent patterns of

interactions among the nodes of a network. Favero's contribution is based on the assumption that the performance of a network depends on the ability of the agents to recognize which connections are worthy to be actualized, and to establish them. Drawing from the historical literature, the chapter discusses these specific aspects of agency and elaborates reflections on the temporality of network evolution.

4 The Contribution of the Book to Network Studies

The book collects contributions that resonate on the eclectic nature of networks and use different analytical and theoretical lens to advance network research and the comprehension of how networks work.

Overall, the book brings out two main reflections. At first, it suggests that regardless the adopted perspective, the relation that exists between network agency and network performance is two-way, meaning that agency and performance are the two faces of the same coin. Agents' behaviour and participation in networks affects network performance and is, under some points of view, a dimension of it. Indeed, a network works when the individuals can coordinate and exploit it as much as possible. On the other hand, network performance influences agents' attitude and becomes part of it when it is used by individuals to participate in the network itself. Further research could thus overcome the traditional separation between performance and agency and focus more on the interactions that govern it and affect the network overall.

Secondly, the book confirms the power of employing alternative lens, contexts and literatures in advancing the understanding of what networks are, how they work and why they perform in a certain way. Drawing from other streams of research is potentially valuable to start new conversations about networks and nurture traditional debates with divergent reflections—for example, ethical reflections on the performance of networks. This may lead to reinforcing network research and enabling its evolution towards having a theoretical valence.

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A Structured Literature Review on Networks and Organizations

Anna Moretti, Sasha Piccione, and Marco Tolotti

1 Introduction

In an increasingly complex economic world, networks have become pervasive of business life. Organizations are then seen as embedded in, and composed by, thick networks of interrelationships that develop at the interpersonal, intra- and interorganizational levels of analysis. In the last two decades, scholarly attention has been largely devoted to networks and organizations, and the field has grown rapidly and, to a certain extent, sparsely. Kilduff and Tsai, in 2003, with their book *Social Networks and Organizations* provided a first systematization of the body of knowledge connecting network theories and methods with organizational research. After two decades from their contribution, the present chapter aims at providing an overview about the field evolution and the

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trajectories that have been taken by scholarly debates in the field. As highlighted by Kilduff and Tsai (2003) and Kilduff and Brass (2010), the distinctive lens that network theory brings to the analysis of a wide range of organizational phenomena made it very appealing to organizational researchers, who used the network metaphor to explore both formal and informal organizations and processes of organizing. Rooted in graph theory, network research met organizations initially through the sociological approaches, but lately incorporating contributions from biology and evolutionary theories, psychology, mathematics, information systems, and more traditional management and organization research. These developments, as noted by Kilduff and Brass (2010), contributed to the exploration of new organizational phenomena, but at the same time, they challenged the coherence of the overall research tradition. The goal of the present chapter is to explore how the study of networks and organizations evolved in the past two decades, understanding if and how the field benefited from the contributions coming from very different disciplines. Our results, based on the analysis of 267 articles published in top journals in the field of management, suggest that the field of networks and organizations has developed along three distinctive lines of research that brings different contributions in terms of methodologies, objects of analysis and openness to contaminations coming from different research traditions. The next section of this chapter presents our methodology for the structured literature review; Sect. 3 presents the descriptive results along the time dimension; Sect. 4 presents the three streams of research defined through a cluster analysis; Sect. 5 concludes this chapter with some final remarks.

2 Methodology

This chapter aims at analysing the main trends and characteristics of the literature regarding networks and organizations in the last 20 years (2002–2021). Following Massaro, Dumay, and Guthrie (2016) we developed a structured literature review, starting with setting boundaries to our research. We decided to use the Scopus database, and we defined the following initial inclusion-exclusion criteria:

- limit the search to papers that were published in 4-star ABS journals (Academic Journal Guide, 2021), in order to describe the evolution of the ongoing debate only in top journals ranked top by a multi-disciplinary list;
- search for the words “network*” and “organiz*” in the keywords indicated by the author, in the abstracts and in the titles. The asterisk allows us to take into consideration all the words that start with the letters by which it is preceded (so networks, networking, organizing, etc.);
- include only finished and published papers;
- consider only papers focused on networks and organizations, excluding papers using the words “network*” to address particular infrastructures (as in information system, for example) and “organiz*” without referring to specific organizational phenomena.

Eventually, such search has provided us with a dataset composed by 486 papers. We qualitatively analysed the dataset obtained with Biblioshiny (Aria & Cuccurullo, 2017) with the aim of developing a general overview of its characteristics and to detect whether the process included also some papers that were out of scope.

Before proceeding with the categorization and the inclusion-exclusion process, we randomly selected 60 papers and collegially analysed them in order to set a clear and shared list of inclusion-exclusion criteria and a definitive table of attributes to run the categorization of articles in the dataset. This first phase of the exclusion process, as the following ones, was carried out utilizing a shared folder on Mendeley so that everyone would be working on the same dataset.

After such testing phase, the remaining articles present in the whole dataset have been randomly assigned to one of the three co-authors in order to decide for inclusion/exclusion from the final dataset based on the titles and on the abstracts. Additionally, the papers that were excluded by one of the authors were randomly assigned to a second co-author for a double check. If a paper was excluded by at least two authors, the exclusion was definitive. Eventually the final dataset upon which we all agreed comprised 299 papers.

We, then, proceeded with the categorization process: we developed a framework with all the relevant categories to classify the articles in the

dataset. Each category was composed by several attributes. While reviewing a paper, each of us would assign an attribute for each category. This phase was preceded by a coder triangulation: a small sample of papers has been categorized by one of the co-authors utilizing the framework (Thurmond, 2004). The aim of this triangulation procedure is twofold. On the one hand, we wanted to see whether the framework we initially designed was capable of fully characterizing the papers that were read or whether some adjustments or additions were necessary. On the other hand, we wanted to make sure that the characteristics of each attribute were clear and consistently shared among the authors.

The definitive framework is represented in Table 1. On the first column we can see the categories, and on the second, the respective attributes. The table provides single attributes definition an exemplificative reference. As it can be seen, the definitive categories had the aim of defining the methodological approach, the characteristics of the object of analysis, the analytical approach and generally the type of research developed.

The in-depth analysis was limited to 279 papers: 20 papers were dropped due to the presence of missing data. Moreover, within this set of papers the analysis highlighted the presence of 12 literature reviews: given their specificities in terms of methodologies and object of analysis, the 12 articles were excluded by our examination, resulting in a final database with 267 papers. In order to explore general trends in the evolution of the study of networks and organizations, we analysed the historical evolution of the research published in the two decades 2002–2021: results are presented into the next section.

3 Historical Evolution

The papers included in our database show a significantly uneven distribution over time, as showed by Table 2. In particular, the first five years of our analysis' timeframe (2002–2006) count for less than the 3% of the total number of papers. In 2007, thanks to a special issue on “Innovation at and across multiple levels of analysis” edited by Anil K. Gupta, Paul E. Tesluk, M. Susan Taylor on Organization Science, the number of published papers on networks and organizations increased significantly with

Table 1 The analytical framework

Category	Attribute	Attribute Definition	Exemplificative Reference
Analytical level	Interpersonal	The Interpersonal level of analysis focuses on relationships between individuals and not from other type of entities (Singh, 2005)	Ahuja et al. (2012)
	Intra-organizational	The Intra-organizational level concentrates on those ties between groups or organization units (Tsai, 2001)	Fang et al. (2010)
	Interorganizational	The Interorganizational level regards networks in which the ties are formed between organizations and the decision to form a relationship (alliance) is taken at the organizational level (Gulati & Gargiulo, 1999)	Furlotti & Soda (2018)
Object of analysis	Ego	The ego is a single subject that, thanks to its position within the network or its personal characteristics, can better perform a specific activity (Haas, 2015)	Khanna et al. (2015)
	Dyad	Dyads are social structures that are composed by two connected subjects (Szulanski, 1996)	Lomi et al. (2014)
	Set of Dyads	Set of dyads, combined, lead to complex structures, such as triads and cliques (Krackhardt & Kilduff, 2002)	Rhee and Leonardi (2017)
	Whole Network	“Network-level analysis of organizational social networks involves investigating system properties that are beyond individual, dyadic, or triadic approaches” (Kilduff & Lee, 2020, p. 14)	Godart and Galunic (2019)
Type of analysis	Theoretical	Theoretical studies aim at enriching the extant literature by either incrementing or introducing novel and original ideas (Corley & Gioia, 2011)	Ryall and Sorenson (2007)
	Empirical	Empirical studies work on network data that the researcher has collected (also indirectly) (Robins et al., 2007)	Kleinbaum (2012)

(continued)

Table 1 (continued)

Analytical approach	Qualitative	A qualitative approach includes data collection methodologies (such as in fieldwork) that allow to have a complex representation of the network that is being analysed (Hoang & Antoncic, 2003)	Operti and Lampronti (2020)
	Quantitative	Quantitative approaches utilize large datasets (with numerous observations) containing, relatively simple, information about the observations (Wagner et al., 2011)	Gulati et al. (2012)
	Experimental	When adopting an experimental approach, researchers utilize particularly numerous simulations with the aim of testing the “plausibility of the assumptions” (Macy & Skvoretz, 1998, p. 646)	Friedkin (2011)
	Literature Review	A literature review gathers the main findings, methods and contributions of the last years with the aim of highlighting the state of art but also potential venue (Podolny & Page, 1998)	Casciaro et al. (2015)
	Conceptual/ Interpretative	Conceptual research does not focus on the data itself, but on the theoretical and conceptual aspects regarding the data, the data collection process or the way in which the network (or part of it) is conceptualized (Whetten, 1989)	Dosi and Marengo (2007)

Type of Network	Business/Formal	Formal networks represent the organizational structure or workflow processes of an organization (Soda & Zaheer, 2012)	Sykes (2020)
	Open/Informal	The informal network regards the relationships that subjects develop autonomously (Krackhardt & Hanson, 1993)	Sterling (2014)
	Process of Organizing	The process of organizing regards networks that are not properly formalized but that, nevertheless, are characterized by an increasing formalization of the rules, dynamics and, sometimes, borders of the network (Ingram & Torfason, 2010)	Choi (2007)
Network stages	Emergence	The emergence of a network is the initial stage of tie formation trying to understand which parameters can favour such process (Grandori & Soda, 1995)	Carnabuci and Operti (2013)
	Evolution	The evolution of a network regards the potential changes in terms of number of participants and ties and, also, in the purpose of ties (Powell et al., 2005)	Leonardi (2007)
	Outcome	The outcome of a network is the "cessation" stage of a network focus on the way in which specific phenomena, dynamics or contingency have influenced on the network (Oliveira & Lumineau, 2019)	Rho and Lee (2018)
Is the study analysing a dynamic process?	The study focuses on a dynamic process	Network dynamics are the changes in a network between two or more timelapses (Snijders et al., 2010)	Shipilov et al. (2011)

(continued)

Table 1 (continued)

Is the study analysing a multilevel network?	The study analyses a multilevel network	A multilevel network is a network composed by different "levels" of networks, each composed by the same subjects, but that are connected by different types of ties (Kivelä et al., 2014).	Battilana and Casciaro (2013)
Is the study analysing a multiplex network?	The study a multiplex network	In multiplex networks we consider different type of ties (relationships) that connect a group of people (Lazega & Pattinson, 1999)	Smith and Papachristos (2016)
Is the network considered as independent variable?	The network is considered as independent variable	When the characteristics of a network are studied with the aim of understanding their impact on a specific phenomenon they are considered as independent variable (March & Sutton, 1997)	Schomaker and Bauer (2020)
Is the study carrying out a social network analysis (SNA)?	The study carries out a SNA	"Social Network Analysis is motivated by a structural intuition based on ties linking social actors, it is grounded in systematic empirical data, it draws heavily on graphic imagery and it relies on the use of mathematical and/or computational models" (Freeman, 2004, p. 3)	McEvily et al. (2012)
Is the study analysing the performance of the network?	The study analyses the performance of the network	The performance of a network can be seen as the combination of "centralized integration, external control, stability and resource munificence" (Provan & Milward, 1995, p. 27)	Clement et al. (2018)

Source: Own elaboration

Table 2 Distribution of published articles over time (2002–2021)

Year	No. of articles	%
2002	1	0.4
2003	1	0.4
2005	1	0.4
2006	4	1.5
2007	15	5.6
2008	5	1.9
2009	6	2.3
2010	11	4.1
2011	18	6.7
2012	24	9.0
2013	14	5.2
2014	22	8.2
2015	28	10.5
2016	16	6.0
2017	24	9.0
2018	26	9.7
2019	11	4.1
2020	23	8.6
2021	17	6.4
Total	267	100.0

Source: Own elaboration

respect to the previous years, starting the positive trend that characterized the subsequent 15 years. In 2012, the famous Special Issue by Ahuja et al. (2012) on “The Genesis and Dynamics of Organizational Networks” pushed the scholarly production beyond the threshold of 20 papers published in a year (24 articles, 9% of the total papers in the two decades); this figure became the average number of papers per year published from then on.

Given the papers’ distribution over time, we propose that the evolution of the field “Networks and Organizations” can be described in three distinct five-year phases, starting from 2007 (the first five-year window, in fact, showed a negligible contribution to the field in terms of number of papers, and its consideration was problematic for the impossibility to compare it to the other five-year time windows): (1) the initial phase (2007–2011); (2) the development phase (2012–2016) and (3) the consolidation phase (2017–2021).

The emergence phase counts 55 articles (21% of the total), the development phase 104 (39%) and the consolidation phase 101 (38%). In the next subsections we propose a detailed analysis of the three phases, using the analytical framework presented at Table 1 as our guidance.

3.1 The Initial Phase (2007–2011)

The scientific production of the initial phase is characterized by mainly two analytical levels: almost half of the papers (49%) adopted an interpersonal level of analysis, while the 44% focused on the study of inter-organizational relationships. The predominant objects of analysis have been the whole-network (51%) and the dyad (33%), and the large majority of these articles (85%) adopted an empirical approach. Within their analysis, scholars used mainly the business/formal organization as the organizational context for their study (71%) and developed their analysis using quantitative methodologies (69%). Notably, in this phase, the SNA approach largely influenced the field, since the 62% of these articles used SNA methods to explore their research questions. While this suggests that the structuralist approach to network studies was largely used, the result on the use of the network as an independent variable by the 62% of the articles implies that in this phase most scholars resorted to SNA concepts to *control for* or *explain through* network features other organizational phenomena. In particular, large attention has been devoted to network outcomes (51% of the papers), namely to the results and effects that network activities or structures can bring to network members individually or collectively, followed by the study of the evolutionary phase of networks (49%), namely to the exploration of the processes and activities characterizing networks' life in terms of changes in the number of participants and ties as well as their purpose. Interestingly, one-third of the articles (33%) proposed an investigation of network dynamics, a topic destined to attract a lot of attention with the Organization Science's call by Ahuja et al. (2012) a few years later. The attention towards network performance started to emerge in this phase, as the 29% of the analysed articles proposed such reflections. The roots of two hot-topics of the

2020s' can be found in this phase as well: 9% of the papers proposed the analysis of network's agents as embedded in multiple set of ties (multiplexity), and the 7% studied networks developed at multiple levels of interaction.

3.2 The Development Phase (2012–2016)

The articles published within the second phase adopted the interpersonal level of analysis for the 62%, while the interorganizational level dropped to the 30%. The intra-organizational level of analysis was adopted by the 14% of papers, namely the highest percentage of the three phases. In terms of object of analysis, as in the previous phase, the whole network was studied by almost half of the articles (47%), while the dyad was studied by almost one out of four articles. The object of analysis that attracted much more attention with respect to the previous five years is the set of dyads, studied by the 30% of the articles. The 77% of these articles focused on the business or formal organization, a percentage even larger than before. Almost the 90% of the studies developed were empirical, and the 80% adopted a quantitative approach: in the development phase, the share of articles with such analytical framework is the largest of the entire period under analysis. The SNA was developed by the 67% of the papers analysed, a percentage slightly larger than in the previous phase (62%). The network variable was used as independent by the 67% of articles, and as dependent by the 40%. As expected, in the development phase the topic of network dynamics was largely studied, with 48% of the papers investigating this issue—the largest share registered for the three phases. The other topic that gets its largest share in the development phase is that of multi-layer networks, even if it remains largely marginal with only 13% of articles using this network conceptualization for their studies. In terms of network evolutionary processes, while the outcome remains the phase on which almost half (49%) of the papers focus, the evolution phase gets more attention with respect to the previous years, being studied by the 55% of the papers.

3.3 The Consolidation Phase (2017–2021)

We called the last five-year window of our analysis the consolidation phase. In this phase, studies of networks and organizations focused mostly on interpersonal (47%) and interorganizational (44%) levels of analysis, while the intra-organizational level was scantily studied (only 9% of articles). In terms of object of analysis, the dyad reached its minimum in terms of share of papers (18%), while the 48% focused on the whole network—a pretty constant trend along the whole period (whose mean, from 2002 onwards, has been exactly 48%). Papers in the consolidation phase started exploring more the informal organization (18%) with respect to the past, at the expenses of the usual business or formal organizational context (68%, the lowest share between the three phases). In terms of analytical approach, empirical papers were still the majority (82%, the lowest percentage of the period), even if we registered an increase in theoretical papers (17%). Interestingly, from a methodological point of view the consolidation phase showed some differences with respect to the previous phases: the 16% of paper used a multi-method approach, the 73% of articles used quantitative methods (the lowest share between phases), and qualitative (17%) and conceptual (11%) approaches registered the highest shares between the three phases. Additionally, also papers using SNA for their analysis decreased, reaching the 55% of all the articles of the consolidation phase. Mirroring these shifts in terms of methodological approaches, the network was used by two-third of the papers (75%) as an independent variable, and by the 26% of papers as a dependent variable. In the consolidation phase, the topic of network performance gathered much attention: 35% of the papers were exploring this issue, the largest share of the whole period.

3.4 Networks and Organizations Across Two Decades

Overall, we note that studies on networks and organizations divided their interest between the interpersonal and interorganizational levels of analysis, leaving largely unexplored the intra-organizational setting. The explanation may be found in difficulties linked to data access, since this type

of contexts require researchers to access team-level data that typically require deep access to organizations and a non-negligible level of trust. In terms of object of analysis, the field started in the initial phase with large attention to the dyad; however, this focus was more and more reduced and shifted towards ego networks and set of dyads. We can interpret such a result as the evidence of networks becoming pervasive of economic life, with their complexity becoming increasingly clear, and management scholars starting to connect organizational phenomena to larger contexts of relationships in which organizational behaviours took place. While the attention of the field has been largely devoted towards formal organizational contexts, in the most recent times we detected the signal of a shift towards the study of informal organizations. As acknowledged by network scholars, informal organizations pose the challenge of data collection, especially concerning the definition of network boundaries. However, digital technologies and social platforms offered the opportunity to explore informal organizations from an innovative point of view that scholars started exploiting in most recent years.

Following a trend similar to that of management and organization studies, the field evolved largely based on the empirical development of quantitative studies; however, probably thanks to the development of more rigorous methodologies for qualitative research (among the others, Gioia et al., 2013), the field showed an increasing interest in qualitative methodologies and mixed methods, as well as theoretical explorations and conceptual analytical approaches. Methods specifically linked to SNA showed a decreasing presence along time, notwithstanding the continuous improvement and sophistication of statistical techniques, now able to represent more complex social phenomena (Amati et al., 2018, 2019). In terms of network processes, studies on networks and organizations delved largely into the evolution and outcome phases, leaving the phase of network emergence still scantily explored. Also in this case, the motivation can be found into the empirical complexities of gathering data on a phenomenon before its actual manifestation or during its very first steps: something made possible often only by the so-called goal-directed networks (Kilduff & Tsai, 2003), when networks are set up and started by agents' intentionality, clearly observable. For what concerns

the “hot-topics” we explored through our analysis, we observe that only network dynamics received significant attention by past research: multi-layered networks, network performance and multiplexity seem to be some promising avenues for future research.

4 The Cluster Analysis: The Three Streams of Research

To explore the characteristics of the body of work on networks and organizations, we developed a clustering analysis that had the scope of grouping the final dataset depending on similarities or dissimilarities between the papers. In order to explore the existence of peculiar and recognizable groups of papers, we run a cluster analysis using as an input all the attributes as described in Table 1. Specifically, dealing with categorical variables, it is more appropriate to work with the so-called *k-modes algorithms* (Huang, 1998). This method defines clusters counting the number of matching categories between data points in the sample. The methodology is run using a Python script. By implementing a classical elbow method, we recognize the number of clusters where mismatches are minimized. After having checked that overlapping among clusters is negligible and that the numerosity of the groups are comparable, it turns out that the best cut-off is at the level three, so we identify three clusters counting, respectively, 59, 102, 94 articles each (12 literature reviews were excluded from this procedure because their features were too far away from other research papers).

To describe the main traits of the three clusters identified through machine learning, we blend two different approaches: (i) a qualitative inspection of the words that are more present in the titles and keywords declared by the authors and (ii) a quantitative analysis to identify the core attributes of the papers belonging to each of the clusters. After having carefully developed these two approaches, we developed an in-depth inspection of the papers belonging to the three clusters, in order to confirm our interpretation of the results presented below.

4.1 The Keywords of the Three Clusters

Figure 1 represents the results of the qualitative inspection through the representation of the word clouds related to the entire sample (panel A) and to the three clusters (panels B–D). The most recurrent words are then reported in Table 3.

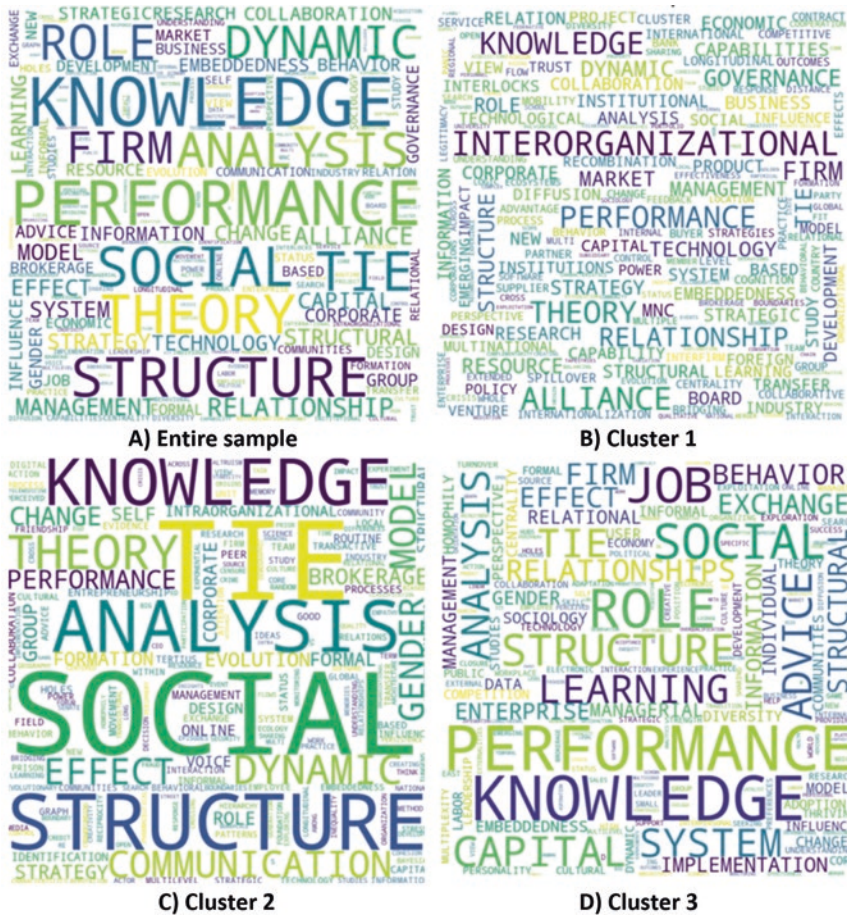


Fig. 1 Word clouds for (A) the entire sample; (B) Cluster 1, (C) Cluster 2, (D) Cluster 3. (Source: Own elaboration)

Table 3 The most recurring words in Titles, abstract and keywords of the three clusters

Cluster 1	Cluster 2	Cluster 3
Interorganizational	Tie	Job
Alliance	Social	Role
Relationship	Gender	Advice
Firm	Effect	Learning
Governance	Change	System
Board	Communication	Capital

Source: Own elaboration

The results highlight that the three clusters showed quite different traits from each other, confirming that commonalities and differences in the papers' attributes (the variables used for the clustering procedure) are reflected also in the articles' contents (recurrent words describing titles, abstracts and keywords).

Table 3 indicates that Cluster 1 covers the topics usually addressed by innovation literature, focusing in particular on strategic alliances, inter-organizational relationships and network governance. Cluster 2, on the contrary, is centred on network concepts (as suggested by "tie" and "social") and covers topics related to social networks dynamics (as suggested by "change" and "communication"). Cluster 3's most recurring words suggest that papers in this cluster are grounded in social network analysis and use the network concepts as a metaphor for knowledge exchange, learning processes and system dynamics.

4.2 The Attributes of the Three Clusters

As a second step to characterize the three clusters, we looked at the attributes as reported in Table 1, and we identified the most persistent traits. Specifically, we computed the proportion of articles in the cluster which showed each attribute. As an example, considering the dimension "Business/formal" organizational context, we see that Cluster 1 shows a score of 0.89, namely about nine out of ten papers have got such trait. By looking at "Evolution", we see that as far as Cluster 2 is concerned, 88% of papers consider such dimension, whereas only 10% of papers in

Cluster 3 do. In order to have a more robust result, we have standardized such results implementing a “Z-scores” transformation. In this way, we can identify the dimensions where the cluster shows a distance from the average value of at least one standard deviation (a Z-score above the value 1). For example, along the dimension “Evolution”, Cluster 2 receives a score of 1.12 (significantly above the mean), whereas Cluster 3 has got -1.13 (significantly below the mean). In Table 4, we report the result of such analysis expressed in terms of the categories we identified in Section “Methodology”. Missing values in the cells refer to situations in which there were no significant values in the Z-score analysis for the category under investigation.

In terms of analytical approaches, in Cluster 1 prevailed the qualitative approach, in Cluster 2 the conceptual/interpretative approach and in Cluster 3 the quantitative one. Generally, research categorized in Cluster 1 focused more on empirical research studying formal organizations and looking at interorganizational relationships based on formal/business ties. Cluster 2 gathers papers aiming at developing theory also through theoretical development. In this cluster are grouped papers that focus on network as the dependent variable and providing contributions on more recent topic of interest of network studies, such as multilevel networks, multiplexity and network dynamics. Papers in Cluster 3 are those focused on social network analysis and using its metrics and measures to explain individuals’ or networks’ behaviours (the network is used as an explanatory variable). Emphasis is given on network performance, reflected also in the focus on the last stage of network development, that of outcome.

4.3 Defining the Three Clusters

The final step of our analysis, to confirm the results presented above, is the in-depth analysis of the articles belonging to the three clusters. Generally speaking, when looking at the papers forming the three clusters, we confirmed the consistency of the results coming from the qualitative and quantitative analysis exposed above on the papers’ keywords and main attributes. Therefore, our results are presented through the clusters labelling and description.

Table 4 The most relevant attributes for the three clusters

Category	Cluster 1	Cluster 2	Cluster 3
Analytical approach	Qualitative	Conceptual/interpretative	Quantitative
Object of analysis	Set of dyads/triads/cliques	Whole network	Ego
Analytical level	Interorganizational	—	—
Type of tie	Formal/Business/Partnership/ Proprietary	—	Advice Network
Type of analysis	Empirical	Theoretical	—
Organizational context	Business/formal	Process of organizing	—
Dependent/Independent variable	—	Network as dependent variable	Network as independent variable
Other properties	—	Multilevel, Multiplexity, Dynamics	SNA, Network performance
Network stages	—	Evolution/Emergence	Outcome

Source: Own elaboration

4.4 Cluster 1: Business Studies and Networks

This group of papers includes all papers related to interlocking directorates, innovation and the discussion about knowledge transfer among organizations linked by formal/business ties. It is characterized by a clear interorganizational perspective, related to the role of formal business ties in enticing the performance of participants in partnerships (such as alliances for knowledge sharing). Here the network perspective is used to describe the relationships connecting business organizations, and topics related to governance of ties, trust, coordination and interorganizational exchanges are treated by this branch of literature. As an example, a significant group of papers is related to the study of interlocking of boards among firms.

4.5 Cluster 2: Networks and Organization Studies

This cluster is more characterized by a network perspective on organizations, not limited to formal ones, but enlarging the scope of investigation to social movements, informal organizations and the process of organizing (e.g. information in web-based platforms). A lot of papers in this cluster discuss social change and informal organizations and are characterized by a sociological perspective. Generally, this group is more focused on the organization structures and the relevance of specific roles in the organization network. Here, the type of tie can be both formal or informal, and the impact of the positioning in a network to the outcome of single actors is addressed by this type of studies.

4.6 Cluster 3: Social Network Analysis and Management Science

This cluster collects a large number of papers related to classical social network analysis at the ego level; the focus is often on single actors and their ego networks. It collects mainly papers based on a structural approach, often related to modelling techniques, mathematical

elaborations and SNA-related methodologies. Often, the main research question is the performance of the network, seen as a “metaphor” for the organization. For example, in this cluster are grouped the majority of studies related to advice networks.

4.7 The Bibliographic Analysis of the Three Clusters

To conclude our analysis of the three clusters, we also performed some bibliographic analysis to identify the reference journals for each group and the respective co-citation networks. Such information, in fact, help in describing the stream of research connected to each cluster and identifying the key ongoing debates. Concerning the journals, Organization Science is by far the more relevant across all clusters, accounting for 78 publications in total. Disregarding Organization Science, the three more represented journals for each cluster are, respectively:

- Business studies & Networks (Cluster 1): *Public Administration Review* (12), *Journal of International Business Studies* (11), *Administrative Science Quarterly* (9);
- Networks and organization studies (Cluster 2): *American Sociological Review* (10), *Strategic Management Journal* (10), *Administrative Science Quarterly* (6);
- Social Network Analysis and Management Science (Cluster 3): *Management Science* (9), *Strategic Management Journal* (8), *Journal of Management* (7).

The fact that *Journal of International Business Studies* (JIBS) collects 11 out of 59 papers reinforces our claim on the relevance of strategic alliances and interorganizational relationships (in the context of MNCs) for Cluster 1. The sociological perspective of Cluster 2 is made clear by the predominant presence of *American Sociological Review* (ASR) and *Administrative Science Quarterly* (ASQ). The quantitative nature of Cluster 3 and the focus on an analytical approach is corroborated by the presence of *Management Science* and the *Journal of Management* among the reference journals of this cluster.

Regarding co-citation networks, that is, the ties that connect two papers that have been cited—at least—twice together by the papers in our dataset, we were able to understand and discern the main theoretical base on which the researchers included in our dataset developed their own theories. Eventually, the ultimate scope of co-citation networks was to individuate and isolate the classics, that is, the papers that were cited the most in each macro-group. For the stream of literature *Business studies and networks*, the three main references were Ahuja (2000), Burt (1992) and Granovetter (1985); for the cluster labelled as *Networks and organization studies*, the main references were Burt (1992, 2004), Borgatti and Foster (2003) and Podolny and Page (1998); for the *Social network analysis and management science* group, the main references were Burt (1992), Brass (1984); Wasserman and Faust (1994). If Burt (1992) can be identified as a milestone transversal to all streams of literature in the field of networks and organizations, the three clusters are confirmed as rooted in different debates within the field: the first closer to management studies, the second closer to economic sociology and the third closer to structural analysis of networks and organizations.

5 Concluding Remarks

The present chapter explored how the study of networks and organizations evolved in the past two decades, through a structured literature review of 267 paper published in top journals in the management field, overall representing the different disciplines contributing to this field of study. The results here presented showed that the literature on networks and organizations has evolved harmonically in three different streams of research that contributed at advancing the field through their different views: the stream on *Business studies and networks* explored particularly interorganizational phenomena linked to knowledge transfer and innovation; the stream on *Networks and organization studies* investigated social phenomena transversal to formal and informal ways of organizing; the stream on *Social network analysis and management science* focused on how social structures impact on individuals' behaviours and performance. The interesting point of our results is that these streams of literature not only

are identifiable for similarities in the phenomena at the centre of their investigations but also for their methodological and analytical approaches. Overall, the results suggest that the multi-disciplinary approach to the study of networks and organizations contributed at advancing our understanding of a broad range of organizing phenomena in the management field, for which networks represent a metaphor, a specific organizational form and a structural pattern of interactions. Notwithstanding the richness of approaches and the appeal that networks represented for management scholars, the results here presented suggest that despite the rapid growth of contributions on networks and organizations, the research tradition has organized coherently around three different streams of research: their acknowledgement and characterization is a first step towards a more clear and tidy evolution of this field of research.

To conclude, our investigation highlighted also some under-investigated areas of research that could be profitably explored by future research. A general trend towards qualitative, theoretical research emerged, even if quantitative and empirical studies are still dominating the field: further exploitation of the opportunities coming from qualitative methodologies and theoretical development could enrich the field in the future, in particular for the *Business studies and Networks* and *Networks and organization studies* streams of literature. In terms of network stages, the emergence phase is still partially uncovered by extant research, probably because of empirical difficulties in gathering data and observing organizational phenomena from the very beginning: in this sense, the methods proper of the *Social network analysis and management science* stream of research, such as theoretical models or agent-based models, could push further the knowledge on this topic. Informal organizations and organizing processes have gained increasing interest in recent times, even if they remain the least investigated organizational contexts. Future research within the *Networks and organization studies* and *Social network analysis and management science* streams could be profitably developed towards this direction. While multi-layer networks, multiplexity and network performance have been under the attention of scholars within the *Networks and organization studies*, these topics are still underdeveloped overall: we encourage future research to focus on these promising and interesting topics.

Appendix: List of the Papers Analysed

Cluster 1: Business Studies & Networks

Abouassi, K., & Tschirhart, M. (2018). Organizational response to changing demands: Predicting behavior in donor networks. *Public Administration Review*, 78(1), 126–136.

Akkus, O., Cookson, J., & A. Horta mcu. (2016). The determinants of bank mergers: A revealed preference analysis. *Management Science*, 62(8), 2241–2258.

Andersson, U., Forsgren, M., & Holm, U. (2007). Balancing subsidiary influence in the Federative MNC: A business network view. *Journal of International Business Studies*, 38(5), 802–818.

Alcàcer, J., & Minyuan, Z. (2018). Local R&D strategies and multilocation firms: The role of internal linkages. *Management Science*, 58(4), 126–136.

Argyres, N., Bercovitz, J., & Zanarone, G. (2020a). The role of relationship scope in sustaining relational contracts in interfirm networks. *Strategic Management Journal*, 41(2), 222–245.

Arya, B., & Lin, Z. (2007). Understanding collaboration outcomes from an extended resource-based view perspective: The roles of organizational characteristics, partner attributes, and network structures. *Journal of Management*, 33(5), 697–723.

Baum, J., McEvily, B., & Rowley, T. (2012). Better with age? Tie longevity and the performance implications of bridging and closure. *Organization Science*, 23(2), 529–546.

Bel, R. (2018). A property rights theory of competitive advantage. *Strategic Management Journal*, 39(6), 1678–1703.

Bell, G., & Zaheer, A. (2007). Geography, networks, and knowledge flow. *Organization Science*, 18(6), 955–972.

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Platform-Enabled Business Models in the Arts: The Impact of Digital Transformation on Visual Arts Networks

Sofia Mogno and Massimiliano Nuccio

1 Introduction

Digital transformation (DT) has radically overturned how organisations plan and run their businesses, affecting processes, business models, sources of competitive advantage and value creation. Involving a process of change, DT asks organisations to develop agile and collaborative competences supporting a culture of relentless innovation through knowledge sharing and cooperation strategies (Warner & Wäger, 2019, p. 344). If establishing an integrated business ecosystem, that is, a network of collaborative stakeholders interrelated more or less informally (Dodgson, 1993, p. 78), becomes pivotal for value creation, at the firm's level, DT fosters the implementation of innovative digital technologies boosting organisational efficiency and effectiveness (Vial, 2019), and, therefore,

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competitive advantage (Paoloni et al., 2020) by creating “differential value” (Mithas et al., 2013, p. 472). In particular, *digital platforms* may enhance the implementation and performance of network-based business models by enabling companies to easily share knowledge and information, human and non-human resources, and culture while ensuring quick and transparent communication among parties.

Although the impact of digital platforms in shaping network dynamics and performance has been analysed in different industries, their role as non-human actors in the arts has been poorly addressed and this chapter wants to fill this gap.

Since the arts and cultural industries create value in multiple ways for a multitude of beneficiaries, with customers (visitors, listeners and audiences) being only one of them, benefitting the whole society (Throsby, 1994), economic value explains only partially value creation in the arts, which can be better described in network terms. However, as digital technologies have significantly affected the visual arts (Baumol, 2006), cultural industries as a whole are urged to develop new business models to capture new opportunities and sources of value creation through digitally enabled networks. This chapter digs into the role of digital platforms within arts networks from an *actor-network theory* (ANT) perspective as it endows both human and non-human actors with agency in analysing network performance. Following Perren and Kozinets (2018)’s framework, therefore, this chapter classifies platform-enabled networks in the visual arts, highlighting both the role and impact of digital platforms on arts networks’ performance through enhanced trust in the exchange and shared value creation (Lerch et al., 2008).

The contribution of this chapter is threefold. First, we want to offer a coherent overview of the different perspectives on arts networks. Second, we make an argument for adopting ANT to explain the role of digital platforms within such networks. Third, by considering some real cases of platform-enabled arts businesses, we offer a taxonomy of platform-enabled business models in the industry to understand the impact of digital platforms on network performance, as actors endowed with agency.

2 Platforms, Networks and the Arts

The paragraph is divided into two parts: the first section reviews the literature concerning the relationship between digital platforms and network performance, while the second one presents network theories applied to the arts with a specific focus on the ANT.

2.1 Platform-Enabled Business Models and Network Performance

The platform economy has witnessed the growing establishment of digitally enabled activities in multiple domains, characterised by new forms of intermediaries that leverage network externalities and economies of scale in the use of consumer data (Nuccio & Guerzoni, 2019). The emergence of digital platforms has radically changed not only socialisation and working processes within organisations but also their value creation patterns, and thus profits, by disrupting and changing the ways in which its multi-sided users interact and engage (Evans & Gawer, 2016) and in which consumption, production and provision of products and services take place (Hein et al., 2020).

The notion of platform may identify both a technology and a business model. In the former case, platforms are conceived as modular structures, composed of multiple and interdependent components in both their architecture and organisational form (Kretschmer et al., 2022). In the second case, digital platforms enable the interaction between distinct but interdependent users including third parties, suppliers, customers, individuals, etc., via internet connected devices and building on a variety of legal arrangements to protect copyright and deliver digital or physical products (Borghetti et al., 2012). In defining an employment taxonomy for platform-enabled business models, Kenney and Zysman (2019) introduce three categories of platform-driven organisations: platform firms, platform-mediated work and platform-mediated content creation. Platform firms are those organisations where value is engendered by platform maintenance, whereas platform-mediated content creation refers to marketplaces and businesses whose value creation processes are

augmented by the platform (e.g., better logistics, direct work, service provision and teamwork). Bonina et al. (2021) classify platforms as either transaction, innovation or hybrid. While transaction platforms promote exchanges between firms and individuals, reducing search and transaction costs for both, innovation platforms support the development of innovative and complementary products or services, with hybrid platforms combining features of both.

This chapter identifies as a platform-enabled business model or organisation a business entity whose business model is built upon digital platforms that connect multiple stakeholders, creating shared value. By matching supply and demand, lowering transaction costs and distributing the costs and risks deriving from market transactions among different participants, platforms enable market-making (Drahokoupil & Piasna, 2017). Therefore, network performance is defined as the creation of shared value for all stakeholders within the network itself. Weill and Woerner (2015) notice that a platform's openness directly affects a network's performance in terms of shared value creation. In network forms, value resides not in one of the firms but in the linkages and structure between them (Alcácer et al., 2016), so that value creation transforms from being an internal firm process into a shared responsibility and outcome, involving the network's participants in co-creation and cooperation processes (Hein et al., 2020). Chesbrough et al. (2018) state that in the era of open innovation, value can be only created and captured by a network of "distributed but interdependent actors" sharing capabilities and knowledge, with dynamic capabilities—namely the ability to integrate and reconfigure internal and external knowledge, competences and skills—being crucial. Kapoor (2018) adds that partners in a platform-enabled ecosystem are connected through mutual interdependencies, aggregating into platform-centred ecosystems for their jointly but partially contributing to a shared core offer.

Hence, digital platforms may enhance network performance by providing fast and responsive connection between the business/producer and its customers, as well as more customised products due to continuous streams of data. They simplify transactions and ease exchanges between involved parties while accelerating innovation through knowledge sharing, shared costs, and lower search and switching costs (Nuccio &

Guerzoni, 2019). Since platforms allow participants to integrate complementary assets, promoting servitisation (Hein et al., 2019), platform design is crucial for facilitating and refining encounters and matches (Evans, 2012). In particular, in networks-based structures, digital platforms allow for wider reach and continuous flows of information and communication, fostering innovation and strengthening relationships. They also boost a network's performance and sustainability because their easing exchange among parties may facilitate network-based innovation (Moro Visconti, 2020). Bearson et al. (2019) argue that platform-enabled value creation does not only pertain to all its related partners but may also affect third parties and intermediaries. This implies that value distribution and creation are mutually dependent, as platforms must aim at both creating and distributing value as beneficial as possible across all partners (Evans, 2012). Thus, platforms can be defined as a collection of assets (i.e., knowledge, people, relationships, processes, etc.), with Gawer (2021) referring to the property of platform-enabled business models of aggregating multiple actants as "multi-sidedness". In this context, value creation is defined through co-creation (or shared) and may be analysed in both monetary and non-monetary terms (Ikävalko et al., 2018) as a measure of network performance.

Since digital platforms enhance both innovation and network development, they become fundamental in the hyperconnected era (Peruchi et al., 2022) for facilitating networks' functioning (Zoppelletto et al., 2020). As markets are defined by not only the pricing mechanisms of supply and demand but also the interactions of interconnected actors in the ecosystem (Peruchi et al., 2022), value creation resides within network, making communication and reciprocity pivotal (Potts et al., 2008) and technology a critical enhancer and mediator (Goodchild & Ferrari, 2021) of both. In their analysis of real estate platforms, Goodchild and Ferrari (2021) recognise how non-human actors (e.g., digital platforms) may support and affect exchanges within networks, acquiring agency by maintaining and establishing market practices through mediacy and intermediacy, allowing consumption and production to meet. Thus, agency is ascribed not only to the single actor but to the whole network multiple and heterogeneous actors belong to, so that innovation becomes a process of consolidation of an idea by assembling diverse allies and

resources (Latour, 1987). As stakeholder diversity positively influences firm's performance through knowledge spillovers, specialised labour and suppliers, digitally enabled networks positively impact on performance within and across firms (Alcacer & Delgado, 2016), making cooperation a necessary condition for value creation in network structures (Alcácer et al., 2016). Since this makes coordination strategic and vital to extract jointly created value (Kretschmer et al., 2022), value creation entails the coordination of multiple stakeholders (Evans, 2012) through complementary intervention and network effects (Ceccagnoli et al., 2012). By ensuring transparency in the exchange, digital platforms promote trustworthiness in the transaction as well, solving network failures (i.e., ignorance and opportunism; Schrank & Whitford, 2011). Hence, not only does communication become a necessary condition for successful network performance, but also trust turns into a critical enhancer and indicator of positive network performance (Lerch et al., 2008).

Digital platforms indirectly enhance an organisation's performance by having a direct positive effect on network (Cenamor et al., 2019) and dynamic capabilities (Linden & Teece, 2018), establishing market practices as a consequence (Kretschmer et al., 2022). If, then, they assume agency within the network (Perren & Kozinets, 2018), the question is how they, as actors, affect network performance promoting shared value creation through enhanced trust in the visual arts.

2.2 Applying Network Theories to the Arts: The Ant

Literature on arts networks has mostly focused on the description and development of network forms, overlooking the impact of digital technology on network business models and performance in the industry. However, from a network perspective, platform-enabled arts networks comprise two industry-specific non-human actors: the artwork and the digital platform. Yet, the latter's role within arts networks is poorly addressed by theory, which fails to account for its agency and impact on network performance. This makes our study of the adoption of digital platforms and their role within arts networks extremely relevant.

From a social sciences perspective, the analysis of the arts has been conducted by sociology and economics with some major implications for

the management of the arts. According to traditional market theory, mechanisms of supply and demand regulate the market with price, which is mostly determined by the customer's willingness to pay. However, this poorly describes the functioning of the arts, which are characterised by a specific type of asymmetrical information or symmetrical ignorance according to Caves (2003). As both the seller and the buyer are uncertain about the characteristics, features, and quality of the final product and object of exchange, long-lasting cooperative forms (e.g., ventures or partnerships) are preferred to reduce uncertainty. On the sociological side, Becker (2008) describes the arts sectors as art worlds. Since an artwork results from dividing labour among various actors through several (often, sequential) stages defined by conventions, relationships of cooperation are depicted as links, upon which an art world is built as a network of all people playing a part in, and cooperating for the final artwork's creation (Becker, 2008). Likewise, Caves (2003) considers arts production as sequential, with multiple individuals' knowhow and capabilities contributing to the final work according to a specific sequence of passages, remarking the challenging assignment and transmission of decision rights across parties involved.

In his definition of "fields" Bourdieu (1996) also shares some similarities with Becker in his focusing on relations, defining the field as a set of historical relations between positions determining competition (Prior, 2008). Yet, while Becker focuses on human relationships between cooperating actors, Bourdieu deals with theoretical ones, designating objective and structural linkages of possibility, difference or interdependence between an art piece and other (previous) works in the field (Prior, 2008). Bourdieu (1996) explains the illusion as the collective rules of the game in arts, which establish the field an artwork belongs to through position-taking, that is, its relative similarity or difference with respect to other works in that field. Nevertheless, both scholars acknowledge the existence of power relationships in the arts: Bourdieu recognises the field of power comprising institutions owing the capital to invest on and support the arts, influencing conventions and, thus, artworks in the field, whereas Becker ponders the importance of patronage in financing the arts.

Like Becker, the social network theory (SNT) focuses on concrete relationships entailing agency and interconnection, defining networks as

“sets of social relationships” (Bottero & Crossley, 2011, p. 106), where each actor is identified by a vertex and is connected to other actors through links (i.e., edges) determining the network’s density and actors’ positions within it. Potts et al. (2008) describe the arts industry as a network, where consumption and production operate as “complex social networks” (p. 8) composed of interconnected individuals whose production and consumption choices are affected by what other actors produce and consume. This makes sharing and cooperation pivotal as “network-valorised choices” (p. 10) become fundamental for generating and capturing the value generated within the network. Similarly, Moro Visconti (2020) describes firms as a network of internal and external contracts established by links (i.e., nexus) among nodes (i.e., all stakeholders involved in the value co-creation). If value is created by all interconnected actors in the network through collaboration (i.e., value co-creation), the responsibility of value creation moves from the single firm to the entire system, including customers, other businesses and competitors (Yaqub et al., 2020). By analysing arts fairs from a network perspective, Yogev and Grund (2012) prove the network effect of arts galleries in the establishment and maintenance of relationships between key actors in the art markets by supporting information flow. While Provan and Milward (1995) claim that network effectiveness decreases with decentralisation and context stability, Arnaboldi and Spiller (2011) prove how actor interdependency and collaboration in cluster systems of multiple interdependent creative entities (i.e., cultural districts) favour value creation and competitive advantage through idea generation. As power is defined by the heterogeneous associations among various actors in the network, it becomes performative and a property of the network. Thus, networks are performative in determining the rules of the game through actors’ agency.

However, all these approaches fail to account for the role of technology in networks. By poorly addressing the role of non-human actors in networks, they offer a limited analysis of the contemporary visual arts industry, which is characterised by networks comprising human actors and two industry-specific non-human actors endowed with agency: the artwork and the technology (i.e., the digital platform). Due to these industry-specific non-human actors of arts networks, the ANT may offer a more enlightening approach to the analysis of value creation in the visual arts

in the DT because ANT considers networks as comprising both human and non-human actors endowed with agency through reciprocal transformation and determination (Latour, 2005). If Latour (2005) addresses the role of the artwork as a non-human actor, which is endowed with agency within art networks for its capability to establish a network and enhance its performance by working as a mediator among parties, ANT fails to examine the role of digital platforms as non-human actors and their agency within arts networks with implications for network performance in terms of value creation. Sele (2021) applies ANT to organisational routines, defining them as networks of (both human and non-human) actors, with the reliance on informal ties (i.e., fluidity) enabling innovation and action in both “cold” (certain) and “hot” (uncertain and ambiguous) situations. Vial (2019) stresses how companies must develop digital capabilities, remediation strategies and platforms for coordinating multiple participants to create new routes of value creation. As non-actants (e.g., technology) positively affect organisational performance (Sele, 2021), Goodchild and Ferrari (2021) ascribe agency to not only a network’s human and non-human actants but also the whole network itself. Therefore, digital platforms not only assume agency within but also ascribe agency to the network they are embedded into. Hence, by considering non-human agency, ANT can effectively address the problem of considering the role of technology—and, in particular, platforms—within arts networks. Yet, if digital platforms have agency and can influence the system, processes and infrastructure of an organisation, how do they affect network performance in the case of platform-enabled arts networks? In the next paragraphs we try to answer this question.

3 A Framework for Classifying Digital Platforms in the Visual Arts

Since the contemporary visual arts industry can be better described through ANT as composed of networks where human actors interact with two industry-specific non-human actors (i.e., the artwork and the platform), our analysis wants to understand how platform-enabled business models affect network performance in the arts. This chapter adopts

Perren and Kozinets (2018)'s framework (see Sect. "Main Findings") to classify platform-enabled businesses in the visual arts.

The framework was applied to eighteen platform-enabled organisations in the arts industry, including arts galleries, museums, marketplaces and auctions of artworks, operating either online and/or offline (see Table 1). Given the exploratory nature of this contribution, the sample is not statistical and was chosen through keyword research on Google Scholar and Google Search to identify "digital arts platforms" and "digital arts business" that could fit our description, making a second selection through deep reading across each organisation's website to confirm the existence of network structures and a core digital platform.

We follow Perren and Kozinets (2018) and define two main functions of platforms, which may work as either intermediaries or mediators of information, or both.

- *Intermediacy* identifies their ability to transport meaning establishing a connection between exchanging parties (*consociality*)
- *Mediacy* implies a modification of it in the exchange (degree of platform *involvement*).

In particular, Perren and Kozinets (2018) classify platform-enabled network models according to consociality and platform involvement levels: the former refers to the co-presence of more than two actors at the same time and in the same (virtual or physical) space, establishing an occasion for interaction and relationship development, whereas the latter to the extent to which a platform affects these exchanges, which is also related to the level of (de)centralisation of the platform itself. Since the successful realisation of exchanges triggers value creation within networks, digital platforms indirectly impact on network performance through mediacy and intermediacy (Goodchild & Ferrari, 2021) by directly affecting shared value creation processes by easing exchange among involved stakeholders.

Table 1 Overview of the art platforms included in the analysis

Organisation	Brief description	Main activities
Platformart	E-commerce	Selling limited-edition artworks from diverse artists, selected in partnership with the gallery David Zwirner, and from a changing group of independent galleries, it does not collaborate directly with artists, but selects partner galleries that both find and buy pieces from artists and manage shipping through third parties, (e.g., FedEx and Fine Art Shipper). It relies on its network of partnering galleries for checking authenticity.
Itsart.tv	Streaming platform	In this streaming-on-demand platform (SVOD) for live events from multiple creative and cultural industries, subscribers can access the event streaming either live or on demand on multiple devices. It has recently introduced exclusive content (e.g., behind the scenes and interviews).
Opensea	Online marketplace of non-fungible token (NFT) artworks	Artists can subscribe, upload their work, add social links, receive statistics about their artwork's performance and manage different payment options, including fixed price, auctions or declining price, and a secondary sales fee.
Studiovisit.me	Search platform	It maps Italian artists, whose profiles include personal and contact info and a gallery of artworks.
Meetingart	Online auction	Auctions of antique and contemporary artworks can take place only online, on demand, live through live-streaming, or traditionally.
Deodato Arte	Online art gallery and e-commerce	The platform works as an intermediary, purchasing pieces from artists, which are sold and shifted to interested buyers through Deodato Arte's e-commerce. It also involves seven physical art galleries across Italy and Switzerland, where art exhibitions are held.

(continued)

Table 1 (continued)

Organisation	Brief description	Main activities
Artsail	Online marketplace	Artists can sell and buyers purchase artworks under seven main categories. Artsail works as an intermediary for (physical) art galleries to sell their pieces to collectors online, indirectly promoting these galleries through a showcase page and by offering their pieces to Artsail collectors and publishes an online magazine.
Makersplace	Online marketplace	Digital creators can create and sell digital artworks, which are certified through blockchain technology, and buyers can buy secured and authentic digital art pieces, which are stored in e-wallets, by auction, on offer or on the spot. Invite-only access upon application filters access to the platform. Creators and collectors can set up their own page to connect with others, check their page views, be followed and display the pieces they created or liked, respectively. In each artwork's page, it is possible to see the ID and offer made by interested buyers. The end user pays fees as the platform credits a 15% commission. It features a secondary market.
Artsted	Online marketplace	It facilitates the encounter between arts collectors and artists, providing the former with blockchain technology and collection tracking and the latter with pricing and promotion tools as well as technology to protect their artwork, including NFT pieces. It provides support with artwork management, analytics and data privacy and security.
LaCollection	Online auction and marketplace	Hosting digital art auctions selling NFT artworks, it provides payment options, authenticity certificates and support in NFT delivery on digital wallets and collaborates with famous museums (e.g., the British Museum) to sell NFT pieces based on famous paintings. It features a secondary marketplace, <i>LaCollection Marketplace</i> .

(continued)

Table 1 (continued)

Organisation	Brief description	Main activities
V-Art.digital	Online platform and marketplace of digital art	Artists can create their own profile, displaying their pieces. Buyers can browse a piece's description, trade history, technical details, authenticity certificate and token details (blockchain included) and the artist's biography, following the artists, as in most social networks. The platform features a virtual studio that can be visited virtually and hosts online events and exhibitions.
Artmajeur	Online marketplace and art gallery	It displays artworks from international artists selected by Artmajeur's art consultants and experts, managing delivery and reimbursements, providing artworks with a certificate of authenticity and online tracking. Collectors can directly contact Artmajeur HQ for personal requests. Artists, art communities and art galleries can register and sell their pieces, paying a commission per transaction, getting analytics about their sales and access to multichannel promotion. Artmajeur displays themed collections with artworks' selections by its experts showcase to guide interested purchasers and publishes a paper and online magazine.
Teelent	Online marketplace and art gallery	It assists subscribing artists in their promotion strategy, creating opportunities for artwork sales and displays, and functioning as an online art shop. Collaborating with national and international organisations (e.g., Florence Biennale), it creates contests for artists to find work opportunities. It cooperates with Artrights to certify and protect subscribing artists' work with blockchain technology. As an online art gallery, it organises virtual events and exhibitions with free attendance.

(continued)

Table 1 (continued)

Organisation	Brief description	Main activities
KnownOrigin	Online marketplace	In this marketplace for selling and collecting NFT art, artists have a personal page, displaying their work, a brief description, main analytics, social network and websites' links, and location. They can gather into online communities, organising projects and contests, setting up online galleries and fairs, where online artworks are displayed and sold. The platform features a six-theme journal and includes a hall of fame, ranking artists, artworks and collectors according to various parameters.
Artsy	Online marketplace	Artists have a dedicated webpage so that buyers and fans can follow them like in most social networks. Both physical and digital pieces are sold. The platform collaborates with galleries, fairs and museums, either hosting online exhibitions or featuring online pieces that can be found in physical venues.
Sotheby's Metaverse	Online auction and immersive space	As the digital auctions section of Sotheby's, it involves sales of both physical art pieces online and NFT pieces, also functioning as an immersive online space for communities of digital art collectors to gather, attend online sales and auctions, and join events.
Superrare	Online marketplace	Buyers can purchase and collect art whereas artists can sell NFT artworks protected and tracked through cryptography and blockchain. It also features multiple communities working as social networks where digital art collectors and artists can interact in metaverse spaces, hosting online exhibitions and museums. The buyer pays a 3% transaction fee, and creators pay a 15% commission on primary sales and receive a 10% royalty on secondary sales.

(continued)

Table 1 (continued)

Organisation	Brief description	Main activities
Ello	Online community platform	Being part of Talenthouse, a network of creative platforms supporting art talent, Ello displays works of multiple artists, who can create a personal page, showcasing their work, and can be followed like in most social networks, and connects artists with brands looking for creative workforce, by exhibiting contests and calls from famous brands.

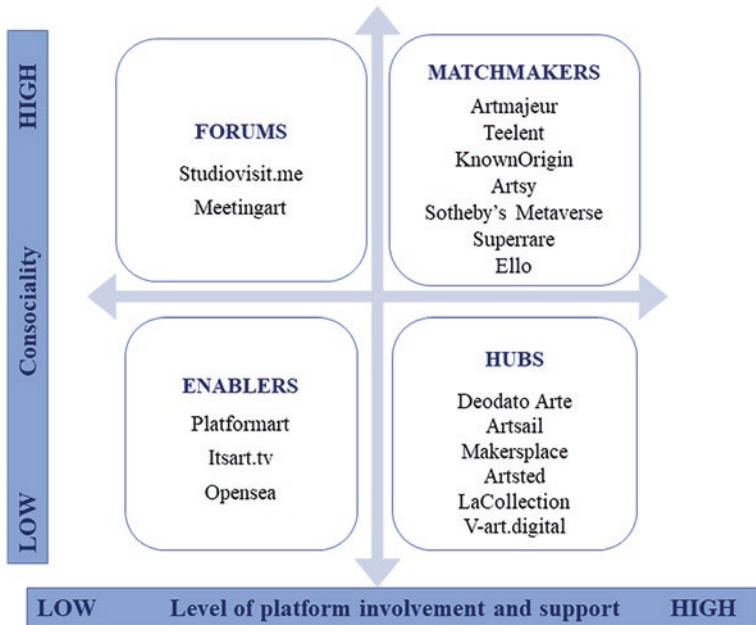


Fig. 1 Classification of platform-enabled business models in the arts. (Based on Perren and Kozinets [2018])

3.1 Main Findings

The following matrix in Fig. 1 positions the cases according to Perren and Kozinets (2018)'s framework.

Arts Enablers (Low Consociality and Low Platform Involvement)

Assisting an actor providing a service to another (Perren & Kozinets, 2018), enablers mostly define websites providing artists' contact information to interested buyers and galleries or content streaming and e-commerce platforms, working as an additional digital retail channel to expand the customer base and geographical distribution of physical art works. The platform provider is not involved in the exchange, reporting low platform involvement, and there is almost or no interaction at all between sellers and buyers. *Platformart*, *Opensea* and *itsart.tv* work as platforms where artists or art companies can sell their pieces online as a marketplace or by uploading their content on the website for users to watch, respectively. This reduces search costs for buyers and provides artists with analytics on their profile performance. If arts enablers mostly entail an online *servitisation* of the core offer, through video-streaming or virtual access to arts exhibitions or marketplaces equipping a network of actors with tools smoothing communication and exchange, performance creates value through improved service provision. However, low platform involvement implies that actors are free in executing their exchanges, as they enforce neither authenticity guarantee nor exchange rules, which makes trust building a major hurdle in this type of business models.

Arts Forums (High Consociality, But Low Platform Involvement)

Forums, also called connectors by Goodchild and Ferrari (2021), connect actors with exchanges directly happening between them. Arts forums provide potential buyers (either individual collectors or art galleries) and artists willing to sell with a matching software. If forums imply low platform involvement, they distinguish themselves from enablers from their higher levels of consociality, as they may involve a physical interaction between the platform operators and either the customer or supplier's sides or both, which may take place even outside the platform in some cases. *Meetingart* allows interested buyers to come to its headquarters to

see and ask questions about pieces, before auctions take place either/both online or/and offline, whereas *studiovisit.me* provides browsing users (e.g., buyers, art galleries and organisations) with information about artists they can contact, buy from or work with outside the platform. Thus, the platform diminishes search costs for people to meet and connect, promoting exchange and then market creation. Yet, like enablers, the main downside of forums is that trust builds on interpersonal relationships, through either physical or virtual interaction, as there is little or no platform involvement in mediating the exchange between parties. In particular, arts forums seem to rely on offline social interactions and meetings to establish long-term trust and relationships, using forums only at the beginning to connect and organise an offline meeting.

Arts Hubs (Low Consociality, But High Platform Involvement)

Art hubs entail two bidirectional interactions between the platform provider and two types of actors (i.e., the seller and the buyer), centralising exchange with (almost) no interaction between these two actors. Entailing low levels of consociality but high platform involvement, hubs mostly define networks of artists and customers, where the interaction between the two sides is limited by platform mediation. Therefore, the particular features of hubs in the arts industry are that the platform promotes the creation of networks where exchanges take place between the platform and the producers (and sellers) or the platform and the customers. They provide sellers (e.g., artists, galleries and museums) with full marketplace and authentication services, working as both a retailer and an art dealer and gallery, holding online auctions and fairs for artists to meet and cooperate. In particular, arts hubs seem to mostly work for the supply side, as they promote the creation of artists' networks that organise online art exhibitions (e.g., *Artsail*).

Arts hubs mostly involve online art galleries and marketplaces, providing risk assurance through authenticity certification and blockchain technology, as well as ensuring exchange transparency and product guarantee by implementing new tools like online face-to-face interaction (streaming) and blockchain (e.g., *Artsted*), filtering the access to the marketplace

(e.g., *Makersplace*), and by creating an additional secondary sale market within the platform (e.g., *LaCollection* and *Makersplace*). Moreover, arts hubs usually take care of the exchange process as well, in terms of product delivery and payment. *Deodato Arte* manages the shipping of pieces after buying them from physical galleries, directly communicating with the final customer. Including some social network features, these are limited to feed comments and follow, implying limited interaction between buyers and sellers (e.g., *V-Art.digital*).

Arts Matchmakers (High Consociality and High Platform Involvement)

Matchmakers pair actors, as the “platform provider mediates” the exchange between multi-sided actors (Perren & Kozinets, 2018, p. 27). While almost all cases represent online marketplaces selling non-fungible tokens (NFT) art pieces, *Ello* is an online marketplace for art workers to offer their expertise to brands in a new way, as the platform creates “spaces” (in this case, online events, or posts, like contests) for them to showcase their work and for brands and artists to connect. Indeed, arts matchmakers are businesses placing a platform at the core of their business model and strategy, using it to ideate, produce, distribute, market and sell the art piece from the producer to the customer. The platform works as a mediator in the exchange between the two by providing customers with authenticity certificates and customer service, and artists with promotions and distribution services. Unlike hubs, they also create occasions and/or spaces for artists and buyers to directly engage and meet, mostly online, through metaverse features, online events and fairs, in addition to social network features such as personal pages and feed comments. If this tries to replicate the virtuosities of physical galleries, where events are held for networking purposes, the advantage of this online option is the flat management and hierarchy, as artists and customers can gather online and organise and hold their own digital gallery or art exhibition online, by creating small communities working as online art galleries within the platform itself, making the need for an organising gallery obsolete. Therefore, this type of platform allows for the development of

networks among multiple parties involved, that is, between the platform provider and the supplier, between the platform provider and the customers, between the supplier and the customers, and between suppliers, customers, and other parties in the platform. Since arts matchmakers boost the possibility for networks to form and easily cooperate and collaborate in the production and distribution of the work of art, they improve performance by reducing transaction and search costs for both buyers and sellers and by fostering the creation of peer-to-peer arts markets.

Moreover, they encourage new ways of creating value and doing business in the industry: they do not only promote the development and establishment of new online arts works and services, such as virtual arts exhibitions, fairs, contests, NFT works and metaverse spaces for buyer-seller interactions, but also further push for new tools to secure and prove art authenticity through innovative blockchain technology (e.g., NFT), metaverse interaction and the involvement of institutions. Indeed, arts matchmakers may sometimes involve institutions (e.g., museums) and experts (e.g., consultants) in the exchange intermediation, easing the development of multi-sided networks, providing online spaces for actors to meet, work and exchange. Thus, matchmaking platforms enhance consociality and mediacy by providing tools for monitoring and promoting sociality between parties, improving trust and exchange, and therefore boosting network performance.

3.2 Discussion

From our analysis, it is possible to notice how the visual arts are experiencing a widespread digitisation in both business models and value creation, with a tendency towards high levels of platform involvement. However, there is a major difference between traditional and digital galleries. While traditional galleries rely on platforms mostly to decrease transaction costs, increase demand, strengthen collaborations between brands and arts organisations, develop and support emerging talent, boosting labour supply in the field, and enhance their performance through additional (online) retail channels, art galleries, which are born

online or sell prevalently or uniquely digital artworks, prefer matchmaking platforms that create value by enhancing network functioning and creating more direct market interactions between sellers and buyers through high levels of consociality and platform involvement.

Mainly two types of organisations use digital platforms to enhance their performance: either marketplaces, selling physical or digital arts, or digital-only art dealers. While the former mostly work as an e-commerce, with low platform involvement and low-to-medium consociality, the latter prefer higher levels of platform involvement and consociality, to facilitate the development of digital art talent and the formation of fans and artists' communities. Therefore, experimentation with platforms seems to characterise mostly digital art organisations.

Moreover, consociality assumes novel features in the arts industry. While Perren and Kozinets (2018) define it as the capacity of a platform to bring users together, boosting their interaction and exchanges (*intermediacy*), in most digital art marketplaces consociality also entails some mediacy, which can be attributed not only to the platform involved but also to the collaboration among its subscribers, who are enabled by platform's innovative technology and tools to organise their own art exhibitions and projects, creating "community-based" digital art galleries. Furthermore, consociality acquires *phygital* features, as the same platform provider may promote the establishment of both online and offline encounters within communities (i.e., networks), depending on the type of actors and organisations involved. Finally, not only platform involvement but also consociality becomes a tool to ensure transparency and authenticity, through online face-to-face interactions, thanks to meta-verse and streaming options, and by including institutional third parties (e.g., museums and the government). This enhances trust in the online product/service and further guarantees product/service quality. Hence, consociality not only creates new markets through new offerings by facilitating and enhancing the interconnection among diverse actors doing art, boosting value creation, but also improves network performance by consolidating trust in the exchange.

In terms of platform involvement in the arts industry, there is a tendency towards elevated levels of platform involvement and support, as platforms are mostly used to develop immersive marketplaces. In particular, online platforms work as additional or main retail channels (e.g., art galleries) where art works can be created, found and sold through enhanced network forms. Hence, high levels of platform involvement improve performance by strengthening the nexus and easing the communication between actors in the network in innovative ways through interactive and immersive tools, and by boosting trust through transparency in payment and product guarantees through blockchain, tracking and metaverse technology. This directly affects consociality levels and quality as well. In particular, platform involvement can take three main forms:

- *Artist or artwork promotion*: the platform could include support through either digital marketing features or digital/physical promotional activities. Therefore, the platform helps art organisations to develop a *phygital* user experience that is seamless across digital and physical domains through metaverse spaces, VR art exhibitions, and online contests and fairs. For instance, promotion could also involve live-streaming and virtual experience in case of live or on-demand auctions.
- *Authenticity and tracking*: most platforms provide artworks with a certificate of authenticity and/or blockchain tracking of ownership and rights, providing artists with legitimisation and customers with security. This enhances authenticity and tracking, and therefore, security in sales, and thus sales volume.
- *Payment and delivery support*: most platforms enable customers to easily pay online artist's artwork, working as payment and distribution mediators, as it usually implies the delivery of the art piece. However, in this case, the platform could work as a mediator between the artist and the buyer, taking responsibility for the delivery itself, or as a mediator between the artists and third parties involved in the delivery (i.e., shipping companies, such as FedEx).

4 Conclusions and Suggestions for Further Research

Our analysis highlights how the ANT approach can contribute to the understanding of contemporary arts networks, which are characterised by two industry-specific non-human actors, that is, the artwork and a digital platform. If the role of the artwork within networks has been studied by the sociological literature, this chapter tries to fill the gap regarding the analysis of the role of digital platforms within arts networks. In particular, we show how the relationships between objects and actors contribute to enhancing arts networks' performance, by applying ANT to the conceptualisation of platform-enabled businesses in the visual arts according to consociality and platform involvement levels.

The contribution of this chapter to network theory is threefold.

First, our analysis shows that digital platforms are crucial non-human actors within arts networks, becoming core elements upon which arts networks are designed and positively affecting network performance through shared value creation by easily transferring agency among actors and promoting trust in the exchange. In general, we emphasise the general tendency towards high levels of platform involvement, with a preference towards important levels of consociality as well, through matchmaking platforms. This applies, in particular, to digital art businesses that exploit platforms for their mediacy and intermediacy, for their advantages as e-commerce solutions and for facilitating community development online.

Second, our analysis shows that, in the arts, digital platforms assume the role of translating actors, as they translate agency from one agent to another. This means that platforms not only hold but ascribe agency within the networks they are embedded into. In their role as translating actors, they improve network performance not only by creating new sources of value creation (i.e., non-fungible tokens, online services and retail, digital archive) and facilitating communication and sociality among parties through cutting-edge technology, but also by strengthening trust in the exchange through improved transparency and authenticity and by lowering barriers to entry for specific actors into the network.

Therefore, the digital platform assumes the role of agency translating non-human actor in the arts, as it enables the interaction (i.e., a process) between actors to take place either in a static (i.e., single transaction) or dynamic (i.e., across multiple transactions over time) way. Thus, arts platforms improve performance through both consociality and platform involvement. Moreover, they not only facilitate the establishment and development of networks of cooperating organisations at a local level but also promote new ways of creating and maintaining such communities, both at a local level and global level. They offer a global batch of talent and artworks, while supporting local realities and micro-artists at the same time (e.g., local independent galleries, shipping companies and art fairs), fostering the development of *glocal* business models and distribution strategies.

Third, platforms strengthen trust among an arts network's actors. According to Lerch et al. (2008), trust is a process indicator in network research, promoting the establishment of a connection between two or more actors and being critical for the long-term existence of a network. Hence, digital platforms strengthen consociality, especially between artists and collectors/buyers, reducing transaction costs and boosting direct-to-consumer (DTC) solutions, disrupting traditional power hierarchies in the industry. Platform-enabled business models do not eliminate hierarchies of power but allow for power to be distributed and shared across diverse parties, who may hold it temporarily, while facilitating tracking and transparency of exchanges through smart technology. Thus, they enhance network performance by solving the problem of rights assignment in the arts over a sequential value chain that was reported by Caves (2003): they have a clear structure of commissions and revenues so that there is no need to draft a new contract whenever new artists or gallery partners engage with(in) the platform, and they automatically and easily track digital supply and distribution chains. This reduces uncertainty for artists and galleries, as well as transaction costs even further, boosting performance. Hence, while Lerch et al. (2008) consider that trust is a premise that network actors should develop over the long term for future advantage and use, digital platforms in the arts allow for trust to be generated between two or more actors involved in a transaction even in the case of short-term or single-time exchange. Therefore, our analysis shows

how trust is not only a process indicator but a crucial enabler for intermediacy and mediacy in platform-enabled business models.

Future research should further investigate the role of non-human agency within arts networks, by studying how it interacts with another non-human actor (i.e., the artwork) and how these two industry-specific non-human actors, in turn, affect network performance.

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Networks and Financial Reporting

Chiara Saccon

This chapter is in the vein of the network evaluation perspective, believing that it is important for entities belonging to a collaborative aggregation, whatever form they take, to be evaluated as a whole and their performance measured, or at least an attempt is made, because the choice whether to collaborate rests on the need to understand and to take informed decisions (Seiler et al., 2020). In particular, the investigation concentrates on business networks and proposes to consider performance measurement and communication through the financial reporting system by adopting the perspective of external stakeholders. In this regard, the problems noted in the literature on network evaluation are taken into consideration and analysed from an accounting perspective and following two different and complementary approaches of analysis, the prescriptive and the descriptive ones (Deegan, 2014; Godfrey et al., 2010).

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The final aim is to propose an alternative and possibly complementing point of view in network evaluation.

The topic of performance evaluation of networks has been addressed by many contributions in the literature over the past years. Among the main issues related to network evaluation, and interconnected between them, are the evaluation criteria and the level of analysis (Sydow & Milward, 2003; Turrini et al., 2010). These two issues raised in the network evaluation literature reflect corresponding aspects of accounting studies that should be conveniently related to each other.

1 Introduction

The evaluation perspective in network studies mirrors the need for assessing the networks performance that is nowadays continuously increasing because of the increasing number of inter-firm organisations.

There is no a single and appropriate network performance (or effectiveness) concept or measure as it depends on the purpose, on occasion of network evaluation and also on the type of network (Sydow & Milward, 2003), but accounting measurements of it, in business networks, could satisfy many information needs by stakeholders related to the networks functioning and represent a sound base for various analysis. Economic measure of firm performance is provided by both branches of an entity accounting system, that is, the financial and the managerial ones.

The analysis of the reasons why the evaluation perspective, and so the performance measurement of networks, is an issue in the network studies agenda, highlights many stakeholders interests and these interests could be fulfilled by the contribution of accounting measures. Evaluating the financial performance of a set of collaborating firms helps to answer questions about which decision to be internally taken, whether or not to join the network, to operate with it, to grant finance, etc.

The importance of extending the domain of accounting across the traditional boundary of the firm towards the networks configuration is not a recent achievement, but it has been highlighted almost thirty years ago (Hakansson et al., 2010a). Accounting measurement methods to determine the performance of organisations have been historically developed

by referring to a vertical relationship between the units within firms. The focus on verticality in accounting has been aimed at designing the boundary of the firm and strengthening the organisational hierarchy (Hopwood, 1996), but it is at odds with the changes in the forms and arrangements of organisations that have occurred over time and that have increasingly emphasised horizontal relationships between independent firms, across legal boundaries. In these new inter-organisational forms, accounting is required to go beyond organisational boundaries. This evolution characterised management accounting research and practice (Scapens & Bromwich, 2001; Chenhall, 2008) for the internal conduct of business networks which has developed considerably over time. The accounting interpretation of networks developed particularly for use within organisations and has therefore concerned management accounting studies (Caglio & Ditillo, 2012). On the other hand, little attention has been paid to financial reporting for external purposes. There is a lack of work analysing the external financial communication aspect of networks, despite the fact that their diffusion is continuously growing as is the attention and information expectation towards them. The general economic information that can be derived from financial reporting can help to assess the conditions of aggregations at the level not only of the individual units in relation to each other but also and above all of the entire network to which they belong to.

2 The Relevance of Network Financial Reporting

The relevance of network evaluation during the last two decades derives from several reasons that highlight a wide range of information needs by stakeholders that could be potentially addressed and answered through network financial reporting.

A first reason is the spread of the business network phenomenon. When the number of networks increases, so does the number of organisations involved in participating and thus the need to assess the convenience of joining (Sydow & Milward, 2003). Similarly, actual and

potential investors, lenders, customers, suppliers and employees of individual firms are concerned with network outcomes for better judgements. Also state agencies and public financial institutions and others involved in supporting networks are interested in their performance evaluation in order to better safeguard the collective interests (Milward & Provan, 1998). In fact, cases of network failure are not infrequent (Barringer & Harrison, 2000); over time there have been examples of how fragile network structures can be and how quickly they can turn against the firms involved (Hakansson, 2010b, p. 348). A precise and thorough evaluation of the benefits of participating in them is necessary for realistic and not merely optimistic forecasts.

These reasons given in the literature, to underline the demand for a network evaluation research and praxi, identify information needs of firms and network stakeholders that financial reports specifically address. Financial reports provide useful information for decision making, and in complex organisations, where there are several levels of stakeholder interest, financial information must respond to those different levels, that is, to the stakeholders interested in the activities and results of the individual unit, but also to the results achieved by the higher level to which the unit belongs, the network level.

Financial reporting provides a synthesis of the performance of firms in terms of wealth, or value creation, the resources and claims, the cash flow generation and consumption (Stolowy & Ding, 2019).

Financial information could play a significant role in the network evaluation, although it has historical nature, because it is a well-known, traditional and accessible information, increasingly understandable for the dissemination of financial literacy among stakeholders or through trained and sophisticated intermediaries. The generality of business entities drawn up mandatory financial statements, comparable at national and also at international levels, and that availability of specific information on each individual entity of a network allows easy aggregation. The convenience for a network to provide financial information is clear because it is configured as an entity that identifies itself separately from its constituent units and must therefore have its own accounting representation as a reporting entity even if it has no legal structure.

In principle all accounting begins from the legal boundaries of the firm because they give the starting point for the identification of what should be taken into account. This leads to difficulties when dealing with issues concerning relationships ‘between’ organisations (Hakansson et al., 2010b, p. 345). Even in the case of corporate groups, the definition of boundaries, to draw up consolidated financial statements, becomes complex when the relationships are not legally clear-cut and may be subject to interpretation (Nobes, 2014). However, most of the relationships between the subsidiaries of a group are established on ‘equity-based’ ties, networks instead are characterised as ‘non-equity-based’ business combinations made up of units that cooperate with each other but are not legally connected. Defining a boundary implies including the relationships between units, but a boundary of a network structure, for accounting purposes, may be created around a chain of companies (Hakansson et al., 2010b, p. 345) with no identifiable relations. For the purpose of economic representation through financial reports, variable configurations of organisations are considered that go beyond legal boundaries in order to adequately respond to the information needs generated by their operations.

Thus, the principle is affirmed that an entity is expressed in accounting terms because its representation is needed and not only, or necessarily, because it has particular characteristics that legally define it. And when organisations are not clearly identifiable as single, defined entities, and instead encompass several units, it is necessary to extend quantitative measurement processes from a single aggregated entity to the entire complex or significant parts thereof (Lai, 1990, p. 148) in order to satisfy the information needs of the various actors at different levels.

Additionally, organisations, in monitoring their activities and processes, use financial performance measures. When these processes are connected to external entities, the focus must extend beyond the boundary of firms, constructing inter-organisational management and network accounting systems (Chenhall, 2005; Caglio & Ditillo, 2012). These systems should better support organisations working within a network and also support the management and performance of the entire network, by monitoring the ability of the network itself to leverage network output.

Despite the importance of an overall evaluation of the network, most research concentrates on the organisational level of analysis considering the impact of inter-organisational relationships upon the performance of the single network unit. Research on inter-firm networks, in both the profit and not-for-profit context, devoted little attention to the issue of comprehensive performance and its determinants. It was believed that improvements in the performance of single entities could be considered as an effect of the overall network success (Saxton, 1997) and the reason for this is the fact that it is easy to attribute results to the activities of individual network components rather than to the network as a whole (Turrini et al., 2010, p. 530).

From an accounting point of view, the performance of single network units, reflecting the benefits coming from the participation to the aggregation, represents the result of a partial value system belonging to a superior one. The measurement of the entire network performance will, in principle, be obtained from the sum of the units' performance due to the uniform expression of accounting information. It will show the network collective outcome also affected by the economic effects of firms cooperation and interdependencies.

Alongside positions that favour the organisational level of analysis, however, there is no lack of research that affirms the prevailing importance of the higher level. Many network evaluation studies concerning the level of analysis issue state that evaluation can and should be approached on different levels of analysis (Sydow & Windeler, 1998; Turrini et al., 2010; Hakansson et al., 2010a; Sydow & Milward, 2003).

According to the network evaluation literature, the appropriate level of analysis depends to a large degree upon the purpose of network evaluation (Sydow & Milward, 2003, p. 4); however, in case of financial information, the simultaneous presence of both tracks of data allows for a more complete, meaningful and useful picture. A step forward is necessary from the "insight that in networks organizational effectiveness should at least be complemented by an assessment of effectiveness on the network level" (Sydow & Windeler, 1998).

Furthermore, the combination of firms' financial statements at the network level will generate financial awareness, that is, understanding and perception of profitability, financial position and the extent of

resources managed by the network overtime. The single firm will be able to evaluate its specific position in the comprehensive organisation and compare the network economic and financial results over periods.

This positive consequence is probably more important for small organisation experiencing less resources for the production of accounting information. Since research demonstrated that small organisations may not find advantages from network activities (Sherrie et al., 2000), financial information at the network level will help a sound assessment of the whole organisation performance aimed at evaluating a conscious participation to networks.

3 The Practice of Network Financial Reporting

The recognition of horizontal relationships between entities and the importance of financial information on networks, to be given specific form, is recognised in some areas of regulation and practice.

In defining a *reporting entity*, that is, an organisation representing itself through financial reports, the international accounting regulation (IFRS—International Financial Reporting Standards) establishes recommendations that undoubtedly highlight the desirability of inter-firm organisations presenting network financial information.

According to international regulation a reporting entity is an entity that is required, or chooses, to prepare financial statements and that can be a single entity or a portion of an entity or can comprise more than one entity (IFRS Conceptual Framework, par. 3.10). Business networks fall into the category of multi-entity organisations, and if they are not obliged to produce mandatory accounting information, it would still be beneficial for them to do so.

Furthermore a reporting entity is not necessarily a legal entity (IFRS Conceptual Framework, par. 3.10) and networks, as organisations without any legal connotation and having relationships non-equity-based between firms, are included here.

Reporting entity that comprises two or more entities, not all linked by a parent-subsidiary relationship, prepares the reporting entity's financial statements that are referred to as "combined financial statements" (IFRS Conceptual Framework, par. 3.12).

The practice of network evaluation is embodied in the so-called combined financial reports. They are comprehensive documents that present financial information of aggregations composed by many independent entities (KPMG, 2022) and offer stakeholders an overview of each linked unit relative position.

In practice, the aggregate information system is obtained by combining individual financial statements and observes the same aggregation methodology as the consolidated financial statements of groups of companies, but differs from it in the absence of the equity relationship between the companies. Consequently, from an accounting point of view, compared to consolidation operations in equity-based groups of companies, the operation to eliminate the participation is not presented. The combined balance sheet is derived from the sum of the assets and liabilities balances of the groups of companies adjusted for items that express interchange relationships between the companies such as receivables and payables between them. Similarly, the revenues and expenses included in the profit and loss account arise from the aggregation net, however, of economic changes generated by inter-company transactions and unrealised gains or losses.

Obviously, the informative value of the network aggregate financial report is higher if the economic connections between the units are significant and the network presents conditions of stability in the long term; on the contrary, the value is reduced if the aggregation is poorly integrated and variable and mobile in composition (Bastia, 1989, p. 189).

A particular form of aggregate balance that takes up the above-mentioned logic of data consolidation for the part of quantitative representation, adapting it to the structure of the network and supplementing it with qualitative information, is that of the 'integrated balance' (Lombardi, 2015). The integrated report aims at assessing the network's performance through the presentation of an organic set of qualitative-quantitative information contained in a synthetic-descriptive section, in which information is expressed on the network's objectives, values and

organisation, and in an analytical section that expresses the aggregation's financial and economic situation, performance indicators and the stakeholder perspective, that is, an evaluation of the network by the stakeholders that emerges from specific surveys.

Combined reporting of business networks is of significant informative value for its ability to give an overall and complete view of the phenomenon. The combination of the value systems of all networked enterprises makes it possible to overcome the limits of partial reporting that the individual financial statements of the networks necessarily provide.

The measurement of the performance of business networks necessarily passes through a joint determination based on the availability of adequate tools for reporting on the aggregate results from both the external and internal perspective of the network (Lombardi, 2015, p. 62).

The business network is an entity in its own right, and in order to meet the information needs of the stakeholders, it is to an overall network financial report that one must resort (Corvino & Mancini, 2008), a report that presents the network's performance and potential development through the sum of all the elements available net of the effects of the intertwining and intersections, both of a capital and income nature, between the network units.

In terms of external communication, aggregated financial statements reveal the magnitudes that express the economic performance of the whole, such as changes in income, turnover and production efficiency, as well as those relating to financial autonomy, equity strength and solvency.

In particular, when networks are in charge of specific production processes on order or participate in international tenders, the complete perception of the aggregative structure by the customer passes through, in addition to an analytical weighting of the factors qualifying the individual companies, an analysis of the entire system that gives an account of the overall productive, commercial, financial and patrimonial assets (Lai, 1990, p. 148). Even for financing institutions, information that gives substance and concreteness to the collaborative links between networks allows a more reasoned assessment of the granting of credit. External users of financial information will not miss the possibility of constantly monitoring the actual or potential benefits of the external growth strategy (Bastia, 1989).

In short, through the financial representation of the whole, the network's equity, financial and income strength is to be conveyed to the various stakeholders, a strength that sometimes leads to the transformation into equity-based groups, which are then called upon to draw up consolidated financial statements.

The production of aggregate financial reports is undoubtedly also useful in the network's internal management processes, in the governance of the network as a management tool (Corvino & Mancini, 2008), making it possible to understand the weight of the relationships in the network's development and the areas of income generation. Summary data are also useful for the planning and control of aggregate actions in order to assess the convenience of collaborative relationships between network firms (Lombardi, 2015).

4 Conclusion

Financial information coming from the firms accounting system, and aggregated to give a whole representation of the inter-firm network, contributes to producing and communicating network performance measurements. This information is useful for stakeholders to understand and assess the economic situation of that reporting entity for decision making purposes.

The difficulties associated with identifying levels of analysis in the evaluation of networks arise in providing relevant financial information and are resolved through the choice of the superior level of analysis, the only one that can provide an assessment of the entire network wealth in which the complementarities and synergies generated by collaboration are also reflected in terms of economic results.

The process of preparing financial information for the network as a whole generates a learning and financial awareness process at the member firm level that influences behaviour both individually and in relation to the whole. Thus, the exchange of accounting information can make cross-borders collaborations more effective (Tomkins, 2001); this is also helped by the fact that accounting information is based on and exploits shared knowledge and ready availability of data.

However, the accounting construction of the representation of financial information on networks is scarcely developed in the literature, and it is the experience of practice, particularly in the preparation of consolidated financial statements, that fills the normative gap.

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Ethics in Organizational Network Performance: Lessons from Organized Crime and Organizational Wrongdoing

Rachele Cavara and Francesco Zirpoli

1 Introduction

Organizational networks are studied more for their positive performance than their dysfunctionalities (Moretti, 2017; Moretti & Zirpoli, 2016; Schrank & Whitford, 2011). Researchers in network studies all agree that network modes of organizing bear many benefits (Moretti, 2017; Provan & Sydow, 2010; Sydow & Milward, 2003). Scholars from the positivist tradition adopt structural approaches to determine, for example, that occupying structural holes in a network creates a competitive advantage (Burt, 1992) or that multiplex ties between partner organizations lead to higher network sustainability in time (Provan et al., 2004). Other scholars who respond to a constructivist paradigm state that an interorganizational

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relationship based on repeated exchange and trust is more stable (Zaheer et al., 1998) and can ultimately produce transaction costs reduction opportunities with respect to market outsourcing (Podolny & Page, 1998). Yet, other researchers have studied network performance “in praxi” (Sydow & Milward, 2003), based on the goals that organizing in networks may attain efficiently in the presence of certain contextual conditions: from economic returns (Podolny & Page, 1998) to production quality (Uzzi, 1997), to learning and innovation (Ahuja, 2000). Taken as a whole, these scholarly pieces of network studies—whether focused on structure, governance, or outcomes—have generated important insights into understanding what network performance, advantages, and functionalities are.

A restricted number of authors, on the other hand, has posited that network modes of governance may also lead to failure, underperformance, or negative outputs (for instance, Baker & Faulkner, 1993; Brass et al., 1998; Moretti & Zirpoli, 2016; Schrank & Whitford, 2011). From a structural perspective, investigations revealed that architectural features such as density (Soda & Usai, 1999), cohesiveness (Gargiulo & Benassi, 2000), or the presence or absence of structural holes (Burt, 1999) can be linked to poor network performance. From a governance perspective, Schrank and Whitford (2011) proposed a theory of network failure based on opportunism and incompetence that are in fact normal attributes of interconnected firms. Moretti and Zirpoli (2016) extended this theory by showing the role that cognitive frames of individual agents involved in interorganizational relationships (and the following mobilization practices) play in explaining network failure or underperformance. Although underdeveloped, the literature on network pitfalls has explained the conditions under which organizational networks fail to be functional or fully functional. But it ignores what happens when a network proves functional in terms of structural features, coordination mechanisms, and goal attainment, and gives rise to an output that is substantially “wrong” from an ethical perspective.

Examples of such networks are gathered from the fields of organized crime and organizational misconduct. Scholars studying the architecture of organized crime, who work at the crossroads of social network theory

and criminology, clearly state that illegal associations benefit from network forms of organizing to implement illegal, unethical, and socially unacceptable behavior (Campana, 2020; Campana & Varese, 2018, 2022a, 2022b; Cavallaro et al., 2020; Gollini et al., 2020; Varese, 2013). Networks present some functioning mechanisms that are indeed more suited to enable illegal activity than market or hierarchy (Kenney, 2007, 2010). Scholars in the field of organizational misconduct also recognize that organizational networks orchestrated some of the most outrageous cases of wrongdoing in history (for instance, Lee and Ermann [1999] for the gas tank ruptures of the Ford Pinto; Muzio et al., 2016 for the Enron scandal; and Nix et al., 2021 for Enron's involvement in the California energy crisis of 2000–2001) and acknowledge that there is still a weak theoretical understanding of the phenomenon in interorganizational terms (Greve et al., 2010; Lee & Ermann, 1999).

The goal of this chapter is thus to highlight and start fixing two important limitations of the literatures studying networks and organizational wrongdoing (where wrongdoing can come from illegal or legal businesses): the first literature misses important types of network dysfunctions by overlooking ethical considerations; the second has limited traction in explaining misconduct when it is generated through networks by conceiving it as a single-organization phenomenon (Greve et al., 2010; Lee & Ermann, 1999). This chapter thus builds a bridge between these two literatures and paves the way (1) to future research on network studies, by addressing the role and impact of embracing ethical considerations in studying network dysfunctions and (2) to wrongdoing analyses, by setting the basis to assess wrongdoing in organizational networks.

In the next section we present the theoretical background on the evaluation of network performance, with emphasis on network dysfunctions. Then, we review how illegal businesses organize in networks to pursue unethical activity. Third, we engage in how legal organizations are said to attain cross-boundaries unethical behavior. Finally, we combine the concepts explained in these sections and discuss the resulting picture.

2 Organizational Network Performance and Unethical Network Outcomes

Network modes of transactional governance are said to be desirable in organizational fields with unstable demand, dispersed competencies, complex interdependencies, and fast-paced knowledge or technological change (Schrank & Whitford, 2011). The automotive or biotech fields and the Silicon Valley district well exemplify where network governance proves more functional than market or hierarchy. The investigation of such network functionality, vis-à-vis that of market and hierarchy in the same context, drove scholars to highlight the advantages of network modes of organizing and the circumstances in which they prove an effective and efficient form of coordination (Podolny & Page, 1998).

However, evaluating network performance is, in many respects, more complicated than it seems (Sydow & Milward, 2003; Provan & Sydow, 2010). First, the multifaceted nature and objectives of organizational networks provide no “one size fits all” evaluation criterion to assess the concept. Second, given their multilayered architecture, multiple levels of analysis can be adopted (e.g., from the individual to the organizational, to the whole network). Third, the focus of attention on network performance changes depending on whether the evaluation is conducted from a structural, governance, or functionalist perspective. Although broadly reviewing network benefits is out of the scope of this chapter, naming some of them is of relevance for the conceptual point we are about to make.

From a structural perspective, network effectiveness is examined resorting to social network analysis concepts or tools. With an input- and normally cross-sectional orientation, studies in this domain rely on architectural explanations of network outcomes to determine the behavioral and economic consequences of specific patterns of actors' interconnections. A seminal work in this field, that bears an individual or organizational level of analysis, is Burt's one on structural holes (1992). Burt stated that occupying the position of a structural hole between two distant actors or groups of actors in a network provides the *tertius gaudens* intermediary with a competitive advantage. This approach resulted in a

broad and dominant literature about the relational understanding of innovation and ideas generation (for instance, Ahuja, 2000; Burt, 2004). Another example of structural analysis of network performance—this time at the whole network level—is Provan et al. (2004) on the multiplexity of ties between partner organizations leading to higher network sustainability in time than simple ties.

From a constructivist perspective, networks are studied in terms of “governance arrangements—namely, coordination mechanisms, processes, and practices developed by network members at different levels of interaction” (Moretti, 2017, p. 12). Works in this stream examine, for instance, how two firms that pursue repeated and enduring exchange relations of production or supply may develop mutual trust, consolidate coordination, and improve the learning process, that in turn end up in reducing the cost of outsourcing through market transactions (Podolny & Page, 1998). Provan and Milward (1995) reflected on how high levels of integration and coordination among actors participating in a network may increase the effectiveness of the whole network.

From a functionalist perspective, authors have focused on the practical outputs that networks may produce efficiently and effectively. Sydow and Milward (2003) state that, at both organizational and network levels, when a focus on outcomes is adopted, the number of criteria to assess the success of a network is almost unlimited: from conventional criteria like survival and innovativeness to diverse ones like client satisfaction, changes in sales or costs, increased or decreased risks, balance of cooperation and competition, network climate, and culture.

All in all, network studies are filled with advantages and benefits of network modes of governance. Notwithstanding, the following doubt arises: can networks still be defined as performing, effective, or successful, if they prove functional in terms of structural features, coordination mechanisms, and goal attainment, but give rise to an output that is considered a form of wrongdoing?

As a matter of fact, well-functioning firm networks have orchestrated some of the most outrageous scandals in the business world due to their pursuit of unethical outcomes. The story of how Enron concealed its massive debts from investors and creditors for a long time involves auditing firms that were unequivocally colluded in the concealment (Muzio

et al., 2016). And the Volkswagen emissions scandal has demonstrably been implemented through the engine control unit (ECU) supplied by Bosch to the carmaker (Contag et al., 2017; Ewing, 2016, 2017). While the dyadic network Enron-Arthur Andersen disappeared, the one between Volkswagen and Bosch is still there and sound.

Literature on organizational networks dysfunctionalities exists, although it is still underdeveloped (e.g., Burt, 1999; Gargiulo & Benassi, 2000; Moretti, 2017; Moretti & Zirpoli, 2016; Schrank & Whitford, 2011; Soda & Usai, 1999). As mentioned above, this stream is interested in understanding how network architectural features or governance mechanisms can be conducive to network failure and underperformance, intended as “the failure of a more or less idealized set of relational-network institutions to sustain ‘desirable’ activities or to impede ‘undesirable’ activities” (Schrank & Whitford, 2011, p. 155). The contributions of this literature provide guidance on how to manage network structure and governance to prevent or fix negative effects or failure. For the way this perspective has evolved so far, however, it evaluates the negative outputs produced by organizational networks based on a conception of the “functionality” of structural features, coordination mechanisms, and goal attainment that completely misses any account or inclusion of the “nature” of the negative output or failure attained. In the specific, such literature does not include as network failure a network that conducts to unethical outcomes.

The reasons for the exclusion can be diverse. First, the focus of this literature is on explaining the antecedents of network failure. The latter is usually considered as the consequence of structural problems or governance dysfunctionalities. So, although the aim of these studies is to explain failure as an output, they rather focus on the hows and whys failure is reached, not on the nature of the output in qualitative terms (e.g., failure of a network because the output is unethical, illegal, or socially illegitimate). The only two works that, to the best of our knowledge, address the problem of “wrong” behavior in social networks (unethical behavior for Brass et al., 1998; illegal behavior for Baker & Faulkner, 1993) do not treat the phenomenon in terms of network failure or network negative output. Second, the literature on network failure does not debate the topic of ethicality likely because it is debated by the literature

on organizational wrongdoing (except that this literature, in turn, does not debate ethicality as a networked phenomenon, as we will see below). Third, governance theories of network failure implicitly assume that it comes from mechanisms that counterpose the parties involved in interorganizational relationships. The attributes of opportunism and incompetence impact the relationship of an organizational actor vis-à-vis the other (Schrank & Whitford, 2011), as well as conflicting framings of agents drive the mobilization of micro dynamics of failure (Moretti & Zirpoli, 2016). While the examples of the networks between Enron and Arthur Andersen or Volkswagen and Bosch mentioned above speak to cases where the parties of the network are collusive in their pursuit of a common unethical outcome. So, some networks result “criminal”, failing or underperforming in a way that is not measurable with the traditional measures and constructs developed by the literature on network failure and dysfunctionalities.

Following these observations, we ask again: can networks be defined as performing, effective, or successful, *or failing, or underperforming*, if they prove functional in terms of structural features, coordination mechanisms, and goal attainment, but give rise to an output that is considered a form of wrongdoing?

Including the ethical dimension in the evaluation of network failure would be of relevance to (1) assess the kinds of outputs produced in the context of failure and (2) contribute to the functionalist assessment of network failure from a new perspective.

Such an approach would also bear concrete implications for studies on the structure and governance of organizational networks. Indeed, the pursuit of unethical outcomes has a remarkable impact on the features of an organizational network, when it is discovered and investigated by social evaluation agents (e.g., judicial authorities). Because social and judicial authorities often impose structural and governance changes to the organizations participating in unethical projects. The *Dieselgate*, for example, reveals quite clearly that Volkswagen was able to settle with the U.S. authorities in the civil procedure only after accepting an independent compliance auditor to supervise for three years that the internal changes in practices and processes imposed by the settlement were

actually implemented. And these changes also involved the network of Volkswagen's suppliers of the ECU design, development, and production.

Literatures on organized crime and organizational wrongdoing support the relevance of the question by demonstrating that both illegal and legal organizations are committed to unethical behavior, as the next two sections clarify. But if the literature dealing with organized crime accounts for the network structure and governance of illegal organizations pursuing unethical behavior, the literature on organizational wrongdoing fails to do so, opening up a gap that can be addressed with constructs provided by the literature on organizational networks, as we will specify.

3 The Network Structure and Functioning of Criminal Organizations

Criminal organizations are born to commit unethical behavior. Be they managing drug trafficking, human smuggling, or Mafia-like activities, their core business is to pursue illegal, on top of unethical and socially illegitimate, behavior (UN, 2004, p. art. 2). For their nature, they need to operate in secret and maintain strategic ambiguity over their functioning or precise goals in order to avoid public scrutiny (Cappellaro et al., 2021). So much so that sometimes wars on criminal organizations fail because of a fundamental misunderstanding of the organizing modes of these trades (Kenney, 2007). Disclosing how illicit organizations are structured and function beyond their opacity is indeed a significant but delicate procedure, since it has to be carried out on blurred realities.

From a structuralist perspective, scholars in the field of organized crime describe that criminal associations deliberately take advantage of network architectures to promote their collective action in hostile environments (for instance, Campana, 2020; Campana & Varese, 2018, 2022a, 2022b; Cavallaro et al., 2020; Gollini et al., 2020; Kenney, 2007, 2010; Varese, 2013). Varese (2013) used the concepts of “vertical” and “horizontal” network to explain the organization of a Russian Mafia cell in Italy that presented local internal hierarchy despite a flat division from the Russian mother cell. Campana (2020) analyzed human smuggling in

the Mediterranean Sea as based on no monopolies but on small, localized, and rudimentary hierarchies. This literature makes clear that criminal organizations take advantage of network architectures more than market or hierarchy because networks guarantee coordination and information processing beyond concealment (Baker & Faulkner, 1993) and resilience to external hostility (Beckert & Dewey, 2017; Beckert & Wehinger, 2013; Cavallaro et al., 2020; Kenney, 2010). The evolution of this descriptive branch of studies uses social network analysis concepts and tools to normatively support enforcement agencies in damaging organized crime effectively. This way, “betweenness” is found as the most effective centrality measure to identify the “largest connected components” in a mafia network (Cavallaro et al., 2020), that are those components to be ideally removed by police raids aiming to perturbate the operations of a mafia network. And the interaction among unidentified criminals is found to be depictable as a “latent space” of interaction of their “ego-networks” and those of their “alters”, who are criminals’ acquaintances not necessarily targeted by police investigations but known to authorities (Gollini et al., 2020).

These structuralist studies, independently from their descriptive or normative goal, demonstrate that unethical behavior put in place by organized crime cannot be fully described or fought if not understood in network terms. To us, this advances the point to consider ethicality as a criterion of evaluation of networks performance.

However, scholars in the structural domain recognize the limitations of pure structural measures in getting to know the nuanced mechanisms of functioning of organized crime (Campana & Varese, 2022b).

Other scholars, influenced by organizational sociology, try to overcome the structuralist limitations by adopting a governance perspective in examining how, in illegal networks, criminals make decisions, pool resources, and engage in collective action within competitive environments. Instructive work in this perspective is that of Kenney on the Colombian cocaine trade. Kenney (2007, 2010) describes the transnational Colombian drug trade as run not by a handful of massive and vertically integrated cartels, like the imaginary around Pablo Escobar and other cocaine trade bosses narrates, but by lots of small, independent groups connected by a network of relations. Normally, the groups are

functionality-specific (farmers, paste/base purchasers, processing labs workers, transportation coordinators, and so on) and represent separate nodes that connect with others in networks of different shapes. This way, groups are kept loosely coupled and personal contact is minimized, in order to avoid the possibility of being red-handed; decision-making is highly decentralized in order to buffer leaders from direct complicity in criminal activity; operations are segmented into small and separate working cells to whom information is given just on a need-to-know basis, in order to reduce communication while ensuring coordination (Kenney, 2007).

Of course, the reasons why criminal networks emerge are different from those of legal networks, given their core to pursue illegal and unethical goals. Notwithstanding, considering the network functionalities of illegal organizations may still be insightful to derive parallels with the network dysfunctions of legal organizations, with a very simple “portability” argument, similar but opposite to the one Baker and Faulkner (1993) used to question the extent to which theories based on legal networks could be generalized to illegal networks. For example, criminal leaders rarely expose themselves to the public and prefer to expose to it nodes of their network of collaborators, family, or friends. This resounds much with the fact that top management in legal organizations is often strategically isolated from the formal decision-making process of a project of misconduct, while white collars are more entrenched in it (Nelson, 2016).

All in all, studies of organized crime support the idea of studying network performance from an ethical perspective, given that they demonstrate that networks can not only pursue unethical behavior, thanks to their structural and governance arrangements, but also pursue it better than market or hierarchy.

4 Networked Unethical Behavior in Legal Organizations

Unethical outcomes can be reached by legal organizations, too. Organization studies have categorized this kind of outcomes as the result of unethical behavior, that is, a form of organizational wrongdoing. In

this section, we present how the literature on organizational wrongdoing theorizes unethical behavior in organizations in a way that does not fully include organizational networks.

Organizational wrongdoing is defined as “behavior in or by an organization that a social-control agent judges to transgress a line separating right from wrong; where such a line can separate legal, ethical, and socially responsible behavior from their antithesis” (Greve et al., 2010, p. 56). According to the definition, the nature of wrongdoing is that of a transgression from legal, ethical, or social frames of reference that takes place in or by an organization. Stating that deviance can be implemented in or by an organization theoretically applies to various modes of governance, because the concept of “organization” can relate to both single organizations and organizations connected by interorganizational relationships such as partnerships, strategic alliances, and organizational networks.

But when it comes to studying interorganizational unethical behavior, things get apparently more complicated and studies in the field often rely on constructs that actually overlook networks as modes of governance. Even authors in the field recognize that “there is not enough research to give clear answers on what kinds of networks and network positions generate misconduct and why” (Greve et al., 2010, p. 94).

From a theoretical perspective, indeed, the emergence of unethical behavior in organizations is always treated as wrongdoing at the level of individual decision-making. In fact, organizational unethical behavior is conceived as the result of individuals making decisions that do not conform to moral standards. This is true if individuals make unethical decisions in a situation of moral awareness (that means referring to a moral framework developed during an individual’s process of cognitive moral development, Blasi, 1980) or in the absence of such an awareness (Tenbrunsel & Smith-Crowe, 2008). In the first case, organizational actors deliberately decide to make an unethical decision against their moral values based, for example, on rational cost-benefit calculations (Zhang et al., 2008). In the latter, the moral dimension of a decision at stake can be temporarily blinded by organizational factors such as routines (Kump & Scholz, 2022), contextual elements such as the institutional environment and organizational culture (Palazzo et al., 2012), or situational contingencies (Treviño, 1986).

Accordingly, the spread of unethical decision-making within organizational boundaries is believed to happen at the level of individuals and to rely on social networks mechanisms such as socialization and contagion (Pinto et al., 2008), or imitation and influence (Greve et al., 2010).

Explanations of the spread of wrongdoing across organizations should involve a different set of plausible accounts than those that are valid intra-organizationally (Greve et al., 2010; Lee & Ermann, 1999). The individual activity of sense making, indeed, which is the precursor of the emergence and proliferation of (un)ethical decision-making, is often played by organizational actors in a complex relationship with contextual factors, as mentioned above. Although this is true for single firms, it may not be as true across organizational boundaries, because across firm boundaries there is no uniform culture, nor socialization of newcomers, nor same leaders with formal authority (Greve et al., 2010).

From an empirical perspective, discussions also leave unclear the role that the relational mechanisms play in cases of interorganizational unethical behavior. The Enron and Volkswagen scandals mentioned above help exemplify what we mean. Enron's culture of placing paramount importance on corporate economic gain (Kulik, 2005) and a high value on cleverness (Sims & Brinkmann, 2003) is studied as having implicitly encouraged rule-breaking inside the organization, as well as the inability of the board to effectively monitor conduct at operational level (Cohan, 2002). Arthur Andersen has been studied for the consequences it bore either from the scandal (Linthicum et al., 2010) or from an institutional environment perspective (Muzio et al., 2016). Accounts of how the relationship between Arthur Andersen and Enron (in terms, for example, of established practices between the two firms) may have been conducive to the unethical scheme are missing. A similar argument can be proposed for the Volkswagen case, whose explanations focus on the carmaker as the only one firm participating in the emissions scandal, from a greenwashing perspective (Aurand et al., 2018; Siano et al., 2017) or from a corporate law perspective (Nelson, 2016) or from a toxic corporate culture perspective (Palazzo, 2019).

The epistemological bias of conceiving unethical behavior as a single-organization phenomenon may have two fundamental reasons: first, the

knowledge of wrongdoing passes most times through investigative or judicial action and sources (Greve et al., 2010; Nix et al., 2021). Judicial action has (and therefore the corresponding data sources implicitly contain) the aim of identifying the person or entity liable for the wrongdoing. If more people or entities are involved in it, they are identified for their specific role in the collective unethical behavior according to specific charges. This drives the bias of thinking that each person or organization did something “wrong” on their own and not in relation to others, and results in a simplified conception of organizational boundaries and the decision-making structure in network organizations. Instead, organizations cannot sometimes be depicted as unitary actors (Whitford & Zirpoli, 2016) and their boundaries are more porous than assumed in a transaction cost economics view and the related exchange-efficiency perspectives (Santos & Eisenhardt, 2005). Second, matters of legal liability impose to investigate and judge the organization that is legally responsible for the misconduct. Meaning that, with reference to one of the mentioned examples, Bosch was responsible for the quality of the ECU supplied to Volkswagen, but only Volkswagen was responsible for the use of the same ECU in the car in front of the regulators. So, judicial action tended to be directed more toward Volkswagen, that was responsible for the wrongdoing under legal liability terms, and less toward other entities that were involved in the defeat device development but were not directly responsible for its use in front of the public. In the end, the aim of judicial action to (1) charge the entities involved in collective misconduct individually and (2) prosecute only those that are legally liable directs the access to information regarding interorganizational wrongdoing toward the concentration on detached and single entities.

In general, scholars in the field of organizational wrongdoing agree that one of the reasons why unethical performance is growing and proving very difficult to stamp out is that there is a weak understanding of how it works in practice, especially when it comes to its interorganizational dimension (Castro et al., 2020; Greve et al., 2010; Lee & Ermann, 1999; Nix et al., 2021).

5 Discussion

The previous sections report the building blocks of our argument on the necessity to evaluate the performance of organizational networks from a business ethics perspective. In the first section, we outlined how the literature on network failure and underperformance adopts a functionalist lens of evaluation focused on the dysfunctionalities that networks structural features and governance mechanisms may bring about. While it misses an ethical evaluation of the negative outcomes that network dysfunctionalities may cause. In the second section, we drew on the literature on organized crime to find evidence that network structure and governance prove functional in producing unethical outcomes in illegal organizations. In the third section, we reviewed a few concepts from the literature on organizational wrongdoing to underline the presence of unethical performance in legal organizations, although this literature fails to account for it when it takes place in organizational networks.

The limitations about the study of unethical behavior in networks may be overcome by bridging the two literatures of network performance and organizational wrongdoing in a way that (1) network studies embrace unethicality in the evaluation of network dysfunctionalities, and (2) misconduct analyses adopt constructs from the field of networks to elaborate on interorganizational unethical behavior.

The relevance of such a bridge for network studies is connected to the fact that we live in a time when network performance is more and more assessed in a broader view than that of managers deciding whether to keep or leave an interorganizational tie. This broader view tends to welcome evaluations of organizational performance at the social and community level, as shown by existing studies that consider the level of the community even more important than that of the network or the network participant in the performance evaluation (for instance, Provan & Milward, 1995). And at a broader level, the community acts as a social evaluation agent of organizations' behavior in terms of ethicality.

The relevance for the literature on organizational wrongdoing would be to become able to tackle the challenge of eradicating (as a consequence of understanding) networked wrongdoing in a time in which unethical

behavior in organizations is growing as a normal phenomenon, very costly for both organizations and societies where it occurs (Palmer, 2013). Indeed, “if scandals no longer dominate headlines as they did when Enron and WorldCom imploded in 2001–2002, that is not because they have vanished but because they have often become routine” (The Economist, 2014).

By embracing an ethical view of network failure and underperformance, future research in network studies may

1. problematize the current conceptualizations of network failure and underperformance. Consider Enron’s and Volkswagen’s scandals, for instance: they have generated from interorganizational networks that had a perfect evolution from the point of view of task partitioning and coordination mechanisms. That is, from a network structural and governance perspective, these networks had produced the expected goals. Nevertheless, they also produced huge financial and reputational losses to the firms involved in the network, in addition to environmental, ethical, and social damage on a case-by-case basis. We maintain that network structures and governance mechanisms (intended as task partitioning, functioning rules, contracts, procedures, etc.) should be held ethically accountable in the assessment of network performance or failure.
2. Contribute to studies of network-level performance (be it positive or negative).
3. Develop a concept of network ineffectiveness that could be defined in opposition to that of effectiveness as the attainment of *negative* network-level outcomes that could not normally be achieved by individual organizational participants acting independently (from the definition of network effectiveness of Provan & Kenis, 2008, p. 230). The issue of network effectiveness is indeed one of the most problematic issues that still needs to be tackled by theoretical and empirical research in this field (Moretti, 2017; Provan & Kenis, 2008), and the fact that organizational networks may produce unethical outcomes at network level may shed light on the concept of network (in) effectiveness.

On the other hand, developing an organizational network view of unethical behavior may help the literature on organizational wrongdoing

1. move away from the individual-level perspective it has had in focus so far. Studies of unethical conduct, indeed, seem blind to the organizational dynamics of nowadays organizations, because they provide explanations of organizational misbehavior relying on the individual or single organization level only—thus, not taking into account the interorganizational context where wrongdoing often takes place.
2. Adopt a “normal” perspective (à la Palmer, 2012, 2013) on corporate wrongdoing, in opposition to the “deviant” perspective (à la Vaughan, 1990, 1996, 1999). The fact that “normal” characteristics of networks may lead to misconduct means that misconduct would become a function of a plethora of omnipresent structures, agents, and processes that are integral to the efficient and effective functioning of organizational networks. And this seems to resonate with, for instance, concealment and decision-making dispersion as functionalities of organizational networks.

Bridging the literature on network performance and organizational wrongdoing would also bear practical implications for managers in connection to the matter of internal network evaluation. Actual practices of evaluation are indeed said to be quite unsystematic (Provan & Sydow, 2010) and simple (Sydow & Milward, 2003), despite the complexity of the issue of assessing a network’s performance. Instead, considering ethicality in the evaluation would add a new transversal and universal intangible factor to internally assess a network’s success or failure.

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How Do Personal Preferences Influence the Flow Dynamics in Networks?

Rosario Maggistro and Raffaele Pesenti

1 Introduction

Networks are a widely used paradigm to describe many kinds of systems, for example, communications, logistics, social, and data. In recent years, the technological evolution has favored that the network literature intermingled with the ones devoted to describing the behavior of very large amounts of agents.

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Within this framework, network scholars debate on defining network performance as the sum of individual members' performance versus the assessment of whole networks' outcome (see, e.g., [1]). From this latter perspective, some confusion still exists about two possible ways of defining network performance: as the ability to reach the collective goal, or as the effectiveness in coordinating members. Moreover, as discussed in [2], network literature suffered from a static/structuralist approach. In particular, the network outcome would be incomplete and partially flawed if we do not look at how individual network members act in their strategic behavior aimed at modifying networks' systems of benefits and constraints for their interests.

From another perspective, we may distinguish between two main lines of studies in the literature. The first one describes agents' behavior in terms of the dynamics of the network. In this case, the network topology evolves, for example, new connections or new vertices may be built or destroyed over time (see, e.g., [3] for a review and research agenda on dynamics of organizational networks). This is the situation, for example, of interfirm networks defined as an institutional arrangement among distinct but related for-profit organizations which are characterized by a special kind of (network) relationship, a certain degree of reflexivity, and a logic of exchange that operates differently from that of markets. Such interfirm networks have been analyzed from different economic and social perspectives, while their inter-organizational effectiveness was first introduced in [1] and subsequently revised under a structurationist perspective in [4] (see also [5]).

The second line of studies describes agents' behavior in terms of dynamics in the network. In this latter case, the network topology remains fixed or, in any case, changes slowly; differently, agents flow dynamically through the network.

Our work falls within the scope of the second line of studies on the networks and provides a small contribution to the literature describing how past experience and available information may influence the behavior of bounded rational agents (see, e.g., Hainer's seminal paper [6]). From a performance perspective, our contribution is in showing how network performance could be defined in terms of effectiveness in coordinating flow dynamics on a fixed network structure. This idea could be assimilated to information flows within intra-organizational networks, to flows of goods and resources in sparse supply chains. From an agency

perspective, our contribution is in providing a model that describes how individual agents' preferences and behaviors may lead to different network performance.

Our approach is based on the mean-field games (MFG) to model the flow of many (theoretically infinite) agents over a network. Specifically, we study how agents moving on a network reach a dynamic equilibrium which is a function of the network congestion. Our results can be exploited by network managers interested in controlling network congestion by making available relevant information.

Mean-field game theory is the study of strategic decision-making by small interacting agents in very large populations, where by small agent we mean an agent who has very little influence on the overall system. More precisely, the idea underlying the introduction of this theory is that, in the case of a large number of agents, interactions are such that each agent only considers the statistical distribution of the others to make his decisions (see [7] and [8]). Several application domains such as economics, physics, biology, and network engineering accommodate MFG theoretical models (see, e.g., [9, 10, 11]). In particular, models to study dynamics on networks and/or pedestrian movement can be found, for example, in [12, 13, 14].

In the present work, we consider the agent's path preferences dynamics in addition to the usual framing of mean-field games (typically defined by the pair made of Hamilton-Jacobi-Bellman and mass conservation equations).

In particular, we propose a model in which the agents choose their path having access to global information about the network congestion, but also being influenced by the decision of agents that has already made their decisions. We assume that an agent that enters the network at the time t first estimates how the congestion of the network will evolve. Then, it individuates the "least expensive" path to reach its destination by evaluating the optimal control (the velocity) that it should implement edge by edge along each possible path. Finally, it makes its choice of the followed path being influenced also by its a priori path preference. The agents' behavior just described makes the evolution of actual network congestion depend on the congestion estimated by the agents when entering the

network. We say that the system has reached an equilibrium when the actual congestion and the estimated one coincide. One possible physical interpretation of our model is to consider the agents as pedestrians traversing possible paths within a city described as a network. However, it may also be seen as well suited to describe car traffic flow in highway networks; and possibly adopted to explain information flows in organizations.

Besides the novelty of the model introduced, the present work aims to introduce the reader to the assumptions that are sufficient to guarantee the existence of a mean-field equilibrium and to forward-backward approach that is generally used to prove it.

The rest of this work is structured as follows. Section 2 describes the model and presents the used hypotheses. Moreover, it analyzes all the agents' dynamics which constitute the transportation system. Section 3 introduces the approach that can be used to prove the existence of a mean-field equilibrium and Sect. 4 presents concluding remarks and highlights directions for future research.

2 The Model

In this section, we describe the flow dynamics over a network of possible paths that the agents can decide to traverse within a time interval $[0, T]$, where $T > 0$ is the final horizon.

2.1 Network Features

We consider a directed network $\mathcal{G} = (\mathcal{V}, \mathcal{E})$, where: \mathcal{V} is a finite set of vertices, and \mathcal{E} is a finite set of directed edges $e = (v_e, \kappa_e)$ being v_e the tail vertex of e and $\kappa_e \neq v_e$ the head vertex. The set \mathcal{V} includes the *origin* o and the *destination* d , where the agents enter and leave the network, respectively. Each edge $e \in \mathcal{E}$ is characterized by three finite parameters: its *length* ℓ_e ; its *flow capacity* C_e , expressing the maximum number of agents that can enter in e per unit of time; and *maximum mass* ρ_{\max} denoting the maximum mass/number of agents that can be present at the same time in e . We assume ρ_{\max} be the same for each $e \in \mathcal{E}$.

An (oriented) *path* from a vertex v_0 to a vertex v_r is an ordered set of r adjacent edges $p = (e_1, e_2, \dots, e_r)$ such that $v_{e_1} = v_0$, $\kappa_{e_r} = v_r$, $v_s = \kappa_{e_s} = v_{e_{s+1}}$ for $1 \leq s \leq r-1$, and no vertex is visited twice, that is, $v_l \neq v_s$ for all $0 \leq l < s \leq r$, except possibly for $v_0 = v_r$, in which case the path is referred to as a *cycle*. A vertex v_j is said to be *reachable* from another vertex v_k if there exists at least a path from v_k to v_j . In particular, we hold the following assumptions on the network \mathcal{G} : i) \mathcal{G} contains no cycles; ii) any vertex in \mathcal{V} can be reached from the origin vertex o and the destination vertex d is reachable from any vertex in \mathcal{V} .

We denote by Γ the set of all the paths p from o to d , by A the $|\mathcal{E}| \times |\Gamma|$ *edge-path incidence matrix* with entries

$$A_{ep} = \begin{cases} 1 & \text{if } e \in p, \\ 0 & \text{otherwise.} \end{cases} \quad (1)$$

and by

$$\Xi = \sum_{e \in \mathcal{E}} \sum_{p \in \Gamma} A_{ep}, \quad \text{with } |\mathcal{E}| \leq \Xi \leq |\mathcal{E}| \times |\Gamma|,$$

the number of the elements equal to 1 of the matrix A , that is, the number of pairs edge-path $(e, p) \in \mathcal{E} \times \Gamma$ such that $e \in p$.

For every path $p \in \Gamma$ and edge $e \in p$, we define the functions $\rho_p^e : [0, T] \rightarrow [0, \rho_{\max}]$, $f_p^e : [0, T] \rightarrow [0, C_e]$, which denote the current mass and current flow of agents following path p , respectively, present and leaving the edge e at each time instant $t \in [0, T]$. We let

$$\rho(t) = \{\rho_p^e(t) : e \in p, p \in \Gamma\} \in \mathbb{R}^{\Xi}, \quad f(t) = \{f_p^e(t) : e \in p, p \in \Gamma\} \in \mathbb{R}^{\Xi}, \quad (2)$$

be the vectors of masses and flows, respectively.

To simplify notations and statements, hereinafter we consider a network \mathcal{G} on which agents have only three possible paths to reach d starting from o (see Fig. 1). Accordingly, the set of paths is $\Gamma = \{p_1, p_2, p_3\}$, where $p_1 = (e_1, e_4)$, $p_2 = (e_2, e_5)$, $p_3 = (e_1, e_3, e_5)$. However, all the results obtained in the next sections can be proved for more general networks, still satisfying the assumptions (i) and (ii) above.

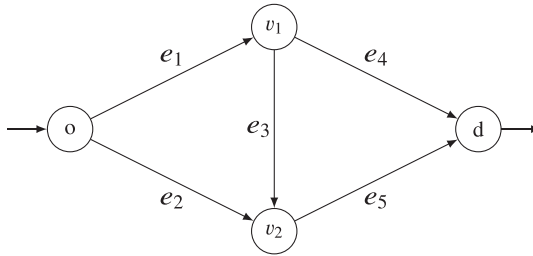


Fig. 1 The network topology used in the chapter

2.2 Agents' Dynamics and Costs

We assume that the agents are indistinguishable and that every agent enters the network \mathcal{G} by the origin o , chooses a path $p \in \Gamma$, travels through \mathcal{G} along p , and finally leaves the network from the destination d . Let $\lambda: [0, T] \rightarrow [0, +\infty[$ be a given function describing the *throughput* of the agents, that is, $\lambda(t)$ is the total flow of agents entering the network in the origin o at time t . In addition, we let $\theta_e \in [0, \ell_e]$ be the state of the generic agent over an edge $e \in \mathcal{E}$. The value $\theta_e(s)$ describes the position of the agent at time s from the tail of e , that is, $\theta_e(s) = 0$ means that the agent is in v_e , while $\theta_e(s) = \ell_e$ means that the agent is in κ_e and hence it is inside the edge e as long as $0 \leq \theta_e(s) \leq \ell_e$. Note that $\theta_e(s)$ describes the state of an hypothetical agent assumed to be in v_e at time t , independently of the fact whether there is actually someone present at v_e at that time. The controlled dynamics in any edge $e \in \mathcal{E}$ of an agent who entered the edge at time $t \in [0, T]$ is:

$$\begin{cases} \dot{\theta}_e(s) = u^e(s), & s \in]t, T], \\ \theta_e(t) = 0, \end{cases} \quad (3)$$

where the control, $s \mapsto u^e(s)$, is measurable and integrable, namely $u^e \in L^1(0, T)$.

Each agent traversing an edge e at a given time t , aims at minimizing a cost that takes into account: (i) the possible hassle of running in the edge

to reach d on time; (ii) the pain of being entrapped in a highly congested edge; (iii) the disappointment of not being able to reach d by the final horizon T . We model this cost analytically as

$$J_e(t, u^e) = \int_t^T \chi_{\{0 \leq \theta_e(s) \leq \ell_e\}} \left(\frac{(u^e(s))^2}{2} + \varphi_e \left(\sum_{\bar{p} \in \Gamma_{e \in \bar{p}}} \rho_{\bar{p}}^e(s) \right) \right) ds + \chi_{\{0 \leq \theta_e(T) < \ell_e\}} \alpha \sum_{j \in p_e} \ell_j, \quad (4)$$

where χ is the characteristic function

$$\chi_{\{0 \leq \theta_e(s) \leq \ell_e\}} = \begin{cases} 1 & \text{if } 0 \leq \theta_e(s) \leq \ell_e, \\ 0 & \text{otherwise,} \end{cases}$$

and similarly for $\chi_{\{0 \leq \theta_e(T) < \ell_e\}}$; $\alpha > 0$ is a constant parameter representing a cost per unit of length, and p_e is the shortest path from the tail v_e to d . The quadratic term inside the integral in (4) stands for the cost component i), while the other term, characterized by the congestion function $\varphi_e : [0, \rho_{\max}] \rightarrow [0, +\infty]$ stands for the congestion cost component. Finally, the last addendum in (4) stands for cost component iii). In particular, note that, due to the presence of the characteristic functions, the integral part is paid as long as the agent stays on the edge e . The cost outside the integral acts as follows: (1) if at the final horizon T the agent is still in between the edge (not reached the head κ_e yet), then the final paid cost is the minimum distance in the network from the tail v_e of the actual edge to the destination d ; (2) if at the final horizon T the agent is at the head of the edge κ_e (i.e., it has already traversed the whole edge), then the corresponding paid cost with respect to the actual edge e is zero. Anyway it will be paid as the minimum distance in the network from the head vertex κ_e to the destination d just by interpreting that head as the tail $v_{e'}$ of any other subsequent edge e' hypothetically entered by the agent at time T .

Throughout this chapter we will assume the following basic assumptions to hold on the agents' behavior:

Assumptions

1. *The throughput λ is $C^1([0, T])$ and $\lambda(t) > 0$ for all $t \in [0, T]$. In particular, this implies that there exist $0 < \underline{\lambda} \leq \bar{\lambda} < +\infty$ such that $\underline{\lambda} \leq \lambda(t) \leq \bar{\lambda}$ for all $t \in [0, T]$.*
2. *The initial mass of agents is null, that is, $\rho(0) = 0$.*
3. *For every $e \in \mathcal{E}$, the congestion cost function Φ_e is Lipschitz continuous. Moreover, it only depends on the masses ρ_p^e and not on the state variable θ_e .*
4. *The network edges' maximum mass is such that $\rho_{\max} > \bar{\lambda}T \geq \int_0^T \lambda(s) ds$ and the flow capacity $C_e > \bar{\lambda}$, $\forall e \in \mathcal{E}$, i.e., neither the mass capacity nor the flow capacity of the edges can impede the agents' movements even in the worst-case scenario.*
5. *When more than one optimal control is available, agents choose the smallest one.*
6. *Agents have bounded rationality in the sense that, even when they access the full available information, the cognitive limitations of their minds, and the finite amount of time they have to prevent them from using the pieces of information to their full extent when making their decisions.*

We now assume that agents entering the network have access to global information about the current congestion status of the network through the knowledge of the actual mass vector ρ . Then, they choose the path to follow on the basis of their appraisal of the costs of the different paths and on the observation of the decision of the agents that have preceded. The relative appeal of the different paths to the agents is modeled by a time-varying non-negative (*aggregate*) *path preferences* vector $z : [0, T] \rightarrow \mathbb{R}_+^{|\Gamma|}$, whose generic element $z_p(t)$ represents the flow's density of agents entering path p at the origin o at time t . The vector z varies within the simplex

$$\mathcal{S}_{\lambda(t)} = \left\{ z \in \mathbb{R}_+^{|\Gamma|} : \sum_{p \in \Gamma} z_p(t) = \lambda(t) \right\}, \quad (5)$$

where we recall that by $\lambda(t)$ we denote the agents' throughput at time t .

The path preferences vector $z(t)$ evolves over time as a function of the appraisal of the costs that the agents would pay along the different paths. The agents assess these costs in terms of the optimal controls that they would implement and assuming known the congestion level described by ρ . Specifically, the assessed cost for each path $p \in \Gamma$ at time t is:

$$J^p(t) = \sum_{e \in \mathcal{E}: e \in p} J_e(t_e^p(t), u_p^e), \tag{6}$$

where, for every $e \in p$, $u_p^e \in L^1(0, T)$ is the optimal control implemented along the edges by an agent who is in the path p (these controls are discussed in the following subsection); $t_e^p(t)$ is the time instant in which an agent, arriving at t in the origin o and following the path p , reaches v_e using the controls u_p^e . We write $t_e^p(t) = \infty$ if an agent does not reach e within T and we define $J_e(\infty, u_p^e) = 0$. This last definition is justified by the fact that the sum (6) must involve non-null costs only for the edges that an agent actually reaches.

We also assume that information on the congestion of the network provided to the agents may be inexact, so that they assess a path p having a minimum cost with probability $e^{-\beta J^p(t)} / \sum_{\hat{p} \in \Gamma} e^{-\beta J^{\hat{p}}(t)}$, where $\beta > 0$ is a fixed noise parameter. Hence, the fraction of agents entering the network at time t that would consider a path p having minimum cost is

$$F_\beta^p(t) = \lambda(t) \frac{e^{-\beta J^p(t)}}{\sum_{\hat{p} \in \Gamma} e^{-\beta J^{\hat{p}}(t)}}.$$

Note that when β tends to 0, then $F_\beta^p(t)$ tends to $\lambda(t) / |\Gamma|$, that is, agents consider all the paths equivalent. Differently, when β tends to infinite the agents have the possibility of surely determining the exact costs of the paths and indeed $F_\beta^p(t)$ tends to 0 for all p , except for the path minimum cost, for which it tends to $\lambda(t)$.

Hereinafter, we denote by $F_\beta(t)$ the vector $\{F_\beta^p(t) : p \in \Gamma\}$ and by $J(t) = \{J^p(t) : p \in \Gamma\}$ the vector of costs on all the paths $p \in \Gamma$. Agents make their final decision on the path to choose comparing the value of $F_\beta(t)$ with the choice of the agents that have preceded them. Specifically, we

assume that they correct the difference $z(t) - F_\beta(t)$ with a proportional control, as described by the following equation:

$$\dot{z}(t) - \dot{F}_\beta(t) = -\eta(z(t) - F_\beta(t)), \quad z(0) = z_0, \quad (7)$$

where, the parameter $\eta > 0$ can be interpreted as the rate at which the path preferences are updated. In other words, Eq. (7) says that the bounded rationality of the agents makes them, on the one side, like the idea to split as indicated by F_β ; on the other side, prefer not to stray from previous agents' decisions. We remark that the dynamics described by (7) makes $z(t)$ satisfies constraint (5) for all $t \in]0, T]$, whenever the same happens for z_0 .

The path preferences vector z turns then useful, to define, for every $t \in [0, T]$ the *local decision function* $G[t]: \mathcal{S}_{\lambda(t)} \rightarrow \mathbb{R}_+^{\Xi}$, which characterizes the fractions of agents choosing each outward-directed edge $e \in p$, $p \in \Gamma$ when traversing a non-destination vertex v . Actually, in this chapter, we are interesting only on the first three components of this functions, (e_1, p_1) , (e_1, p_3) , (e_2, p_2) , which are relative to the two edges e_1, e_2 outgoing from the origin o (see Fig. 1). We restrict our attention to these three components since once the path is chosen in the origin, in the following non-destination vertices the agents get split according such a choice.

Hence, we define the first three component of $G[t]$ and fix the others equal to zero as follows:

$$G[t]_p^e(z) = \begin{cases} \frac{z_p}{\sum_{\hat{p} \in \Gamma} z_{\hat{p}}} & \text{for } e \in \{e_1, e_2\}, p \ni e, \\ 0 & \text{for } e \in \{e_3, e_4, e_5\}, p \ni e. \end{cases} \quad (8)$$

Note that in (8), for every $t \in [0, T]$ and for every $z \in \mathcal{S}_{\lambda(t)}$, it is $\sum_{\hat{p} \in \Gamma} z_{\hat{p}} = \lambda(t) \geq \underline{\lambda} > 0$, because of (5) and Assumption 1.1. Hence, for every $t \in [0, T]$, $G[t]$ is a continuous function defined over the compact set $\mathcal{S}_{\lambda(t)}$, and so uniformly continuous. Definition (8) allows to write the equation that describes mass conservation, for every vertex $v \neq d$ and outward-directed edge $e \in p$, $p \in \Gamma$, as:

$$\dot{\rho}(t) = H(f(t), z(t); t), \quad \rho(0) = \rho_0, \quad (9)$$

where the flow $t \mapsto f(t) = (f_p^e(t))_p \in \left(\prod_{e \in \mathcal{P}} [0, C_e]\right)_p$ is defined next, $t \mapsto z(t) = (z_p(t))_p \in \mathcal{S}_{\lambda(t)}$ is the solution of (7), and $H : \prod_{e \in \mathcal{P}} [0, C_e] \times \mathcal{S}_{\lambda(t)} \rightarrow \mathbb{R}^\Xi$ is defined, for every $t \in [0, T]$, by

$$H_p^e(f(t), z(t); t) = \left(\lambda(t) G[t]_p^e(z(t)) + f_p^{prec_p(e)}(t) \right) - f_p^e(t), \quad \forall p \in \Gamma, e \in p, \quad (10)$$

with $prec_p(e)$ the function that returns the edge that precedes e on the path p . Each component $f_p^e(t)$ of the flow $f(t)$ represents the outgoing flow from the edge e at time t . Given Assumption 1.6, agents assess the outgoing flow assuming a minimal length of the traverse time interval, $k \in]0, T]$, for each edge $e \in \mathcal{E}$. Specifically, k is assessed as the minimal length of a time interval such that to cross the edge in less time is certainly non-optimal, as the traversing cost would be for sure greater than the cost of non-traversing, given by the disappointment of not being able to reach the destination d at time T . Actually, such a value $k > 0$ can be a priori evaluated by the data of the problem. Then, we write the outgoing flows as:

$$f_p^e(t) = \begin{cases} 0 & \text{if } t \in [0, k], \\ \lambda(t-k) G[t-k]_p^e(z(t-k)) \text{sign}(u_p^e[t-k]) & \text{if } t \in [k, T], \\ \text{for } e \in \{e_1, e_2\}, p \ni e, \end{cases} \quad (11a)$$

$$f_p^e(t) = \begin{cases} 0 & \text{if } t \in [0, k], \\ f_p^{prec_p(e)}(t-k) \text{sign}(u_p^e[t-k]) & \text{if } t \in [k, T], \\ \text{for } e \in \{e_3, e_4, e_5\}, p \ni e, \end{cases} \quad (11b)$$

where $u_p^e[t-k] \geq 0$ is the constant optimal control implemented by an agent that, following path p , enters the edge e at time $t-k$, and $\text{sign}(\xi) = 1$ if $\xi > 0$ and $\text{sign}(\xi) = 0$ if $\xi = 0$.

Remark 1 Conditions (11), coherently with Assumption 1.6, model the outgoing flows $f_p^e(t)$ as possibly estimated by an agent entering e at time $t-k$ that assumes that all the other agents that are currently present on e and that are following the same path p , are implementing the same controls $u_p^e[t-k]$, as itself. Hereinafter, the flows (11) are sometimes called “estimated flows.” Of course, a more precise formulation of them should consider the actual value of the control (and not only its sign) and estimate the real traverse time (something similar in this direction is made in [14]). Similarly, the mass ρ that satisfies (9) may be more precisely defined to represent the real dynamics of the agents. Anyway, such estimated flows and mass evolution may be also seen as an approximation for the elaboration in real time of the information that a possible network manager has to implement and to send them to the agents. The study of the real discrepancy of such estimated flows and mass evolution from the actual ones may be the subject of future works. However, note that the estimated flows f_p^e (11), when implemented in (9), make the principle of mass conservation satisfied. Finally, let us observe that (9)–(11) do not preclude the possibility that agents accumulate at the beginning of an edge e , that is, on the vertex v_e . This situation may occur, when the optimal control is $u_p^e = 0$, since the corresponding outflow $f_p^e = 0$.

3 Value Functions and Optimal Controls

Given a vector mass concentration $\rho(\cdot)$, for each $p \in \Gamma$, $e \in p$ and $t \in [0, T]$, the following functions represents the optimum cost that an agent, entering edge e of a path p at time t , must pay:

$$V_p^e(t) = \begin{cases} \inf_{u_p^e \in L^1(0,T)} \left\{ \int_t^{T \wedge \tau} \left(\frac{(u_p^e(s))^2}{2} + \varphi_e \left(\sum_{\bar{p} \in \Gamma | e \in \bar{p}} \rho_{\bar{p}}^e(s) \right) \right) ds + \mathcal{F}_p^e(T \wedge \tau) \right\} \\ \text{if } e \in p \setminus \{last(p)\}, \\ \inf_{u_p^e \in L^1(0,T)} \{J_e(t, u_p^e)\} \text{ if } e = last(p), \end{cases} \quad (12)$$

where τ is the first exit time from the closed interval $[0, \ell_e]$, $last(p)$ is a function that returns the last edge of a path p and $\mathcal{F}_p^e(T \wedge \tau)$ is given by

$$\mathcal{F}_p^e(T \wedge \tau) = \begin{cases} V_p^{succ_p(e)}(\tau) & \text{if } \tau < T, \\ \alpha \sum_{j \in p_e} \ell_j & \text{if } \tau > T, \\ \min \left\{ \alpha \sum_{j \in p_e} \ell_j, V_p^{succ_p(e)}(\tau) \right\} & \text{if } \tau = T, \end{cases}$$

with $succ_p(e)$ the function which returns the edge that follows e on path p , for $e \in p \setminus \{last(p)\}$. Functions $V_p^e(t)$ can be recursively and backwardly computed, starting from the ones corresponding to the last edges ending in the destination vertex d . We call them, with a little abuse of terminology, *value functions*. Note that such a recursive definition is valid as the absence of oriented cycles in the network \mathcal{G} prevents self-referring. Note also that $\mathcal{F}_p^e(T \wedge \tau)$ may be discontinuous in τ . This fact implies the possible discontinuity of the Hamiltonian associated with the value function and/or of the boundary data. Hence, we will write, as in [14], optimality conditions in terms of the value functions for the exit-time/exit cost problem on each edge. The value functions do not take into consideration the position θ_e of the agents on the edges due to the hypothesis that the congestion functions φ_e depend on the total mass actually present on the edge and not on the state position of the single agent.

The considered value functions imply that, for each $p \in \Gamma$, $e \in p$, the optimal control implemented by an agent that, at time $t \in [0, T]$, starts to traverse the edge e as part of the path p is either

$$u_p^e \equiv \frac{\ell_e}{\tau - t} \quad \text{or} \quad u_p^e \equiv 0. \quad (13)$$

Once t is fixed, the control in (13) is constant.

Hereinafter, we denote by $u_p^e[t]$ the optimal control chosen by an agent that stands in v_e at time t when following the path p and by $u[\cdot] = \{u_p^e[\cdot] : e \in p, p \in \Gamma, u_p^e[\cdot] \geq 0\}$ the vector of these controls.

Consider now the network as Fig. 1 we can determine the optimal controls on each edge and the corresponding value functions using backward dynamic programming.

An agent standing at v_e at time $t < T$, and hence at $\theta_e(t) = 0$, where $\kappa_e = d$, that is, for the pairs $(e, p) \in \{(e_4, p_1), (e_5, p_2), (e_5, p_3)\}$ has two possible choices: either staying at v_e indefinitely or moving to reach $\kappa_e = d$ exactly at time T . Accordingly, the candidate constant optimal controls to be chosen at the time t are

$$u_{p,1}^e[t] \equiv 0, \quad u_{p,2}^e[t] \equiv \frac{\ell_e}{T - t}. \quad (14)$$

Hence, given the cost functional (4), we derive

$$V_p^e(t) = \min \left\{ \alpha \ell_e, \frac{1}{2} \frac{(\ell_e)^2}{T - t} \right\} + \int_t^T \varphi_e ds. \quad (15)$$

Given the above value functions, we can proceed backward. As an example, we consider $V_{p_3}^{e_5}(\tau)$ to determine the optimal control of an agent standing in v_{e_3} at time $t \in [0, T]$. It has two possible choices: staying in v_{e_3} or moving to reach κ_{e_3} at some (optimal) instants $\tau \in]t, T]$. Hence, The agent has to choose between the following two candidate constant optimal controls:

$$u_{p_3,1}^{e_3}[t] \equiv 0, \quad u_{p_3,2}^{e_3}[t] \equiv \frac{\ell_{e_3}}{\tau - t}, \quad (16)$$

whose associated value function is:

$$V_{p_3}^{e_3}(t) = \min \left\{ \alpha \left(\ell_{e_3} + \ell_{e_5} \right) + \int_t^\tau \varphi_{e_3} ds, \inf_{\tau \in [t, T]} \left\{ \frac{1}{2} \frac{(\ell_{e_3})^2}{\tau - t} + \int_t^\tau \varphi_{e_3} ds + V_{p_3}^{e_3}(\tau) \right\} \right\}. \quad (17)$$

Iterating a similar argument, we can determine the optimal controls and the value functions of all the agents that are entering an arc e of a path p at time t .

We remark that the minimization processes in τ are admissible because of the coercivity of the minimizing term when $\tau \rightarrow t^+$.

4 Existence of a Mean-Field Equilibrium

The procedure to prove the existence of a mean-field equilibrium for ρ over the considered network \mathcal{G} is discussed in this section. We proceed as follows: first, we choose the space of functions to search for a fixed point, that is, for a function ρ which describes the desired mean-field equilibrium. We choose

$$X = \left\{ w : [0, T] \rightarrow [0, \rho_{\max}] : L(w) \leq \tilde{L}, |w| \leq \rho_{\max} \right\}^\Xi, \quad (18)$$

that is, the Cartesian product Ξ times of the space of Lipschitzian functions w with Lipschitz constant $L(w)$ not greater than a constant value \tilde{L} and overall bounded by ρ_{\max} . Space X is convex and compact with respect to the uniform topology.

Then, fixed the noisy parameter $\beta > 0$, we search for a fixed point of the function $\psi: X \rightarrow X$, with $\rho' = \psi(\rho)$ where ρ' is obtained performing the following steps (see diagram in Fig. 2):

- (i) Given the mass ρ the optimal control u is derived as described in the previous section;

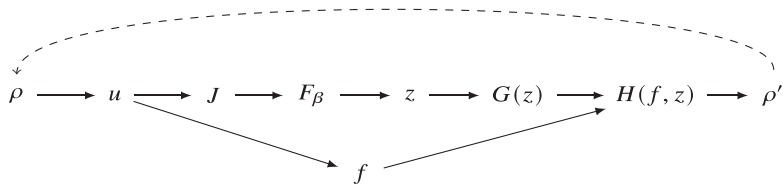


Fig. 2 Fixed-point scheme

- (ii) The optimal control u is used both to compute the flow vector f through (11) and to obtain the path preferences vector z through (7) by first computing the vector of costs J and thus the vector F_β ;
- (iii) The mass vector ρ' is derived from f and z through (9) by first computing the vectors G through (8) and H through (10);
- (iv) We set $\rho = \rho'$ and we iterate steps (i)–(iii) until we converge to a value ρ which satisfies $\rho = \psi(\rho)$.

Note that a suitable constant \tilde{L} exists such that the function ψ maps X into itself. Indeed, note that, by construction, $\psi(\rho)$ must satisfy (9) and hence, by Remark 1 and Assumption 1.4, the bound $\|\rho\| \leq \rho_{\max}$ is satisfied and, as Lipschitz constant we can take $\tilde{L} = 3\bar{\lambda}$.

Finally, the following theorem guarantees that the above procedure converges.

Theorem 1 *Given Assumptions 1, a mean-field equilibrium, that is a total mass $\rho \in X$ that satisfies $\rho = \psi(\rho)$, exists.*

The proof of the above theorem is out of the scope of the current work. The proof would show that if ρ is continuous and Assumptions 1 hold, then every value function defined in the previous section is: Lipschitz continuous, with Lipschitz constant independent of ρ ; bounded independently on ρ ; continuous with respect to the mass density ρ . Then, it would exploit this fact to prove that ψ is continuous (see [15]) so that we can apply the Brouwer fixed-point theorem which in turn guarantees the existence of a mean-field equilibrium.

5 Conclusions

In view of the link among the network literature and the one aiming to describe the crowd's behavior, in this work we have introduced a novel mean-field game model to represent the agents' flows over network. Our model takes into account the agents' preferences about the path choices and, in particular, the fact that the agents choose their path on the basis of both the network congestion state and the observation of the decision of whom have preceded them.

We have also introduced a set of conditions that are sufficient to ensure the existence of a mean-field equilibrium. Possibly, the strongest condition is the one assuming the absence of (oriented) cycles in the network. This assumption may limit the application of our work to the description of information flows only for particular organizational networks, for example, the ones characterized by a hierarchical structure.

In light of the above considerations, our model can be framed in the literature on network performance and on how individual agents' preferences and behaviors may influence it.

Our future research will look at how far it is possible to relax the conditions introduced in this work and still ensure the existence of a mean-field equilibrium. In addition, it will investigate deeper the connection between network equilibrium and network effectiveness.

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Networks in Practice: Insights from the Routine Dynamics Perspective

Lisa Balzarin

1 Introduction

Networks—being them interpersonal, intraorganizational or interorganizational—are not only tools to represent interconnections among actors, but they are actual forms of coordination and of organizing social and business activities. They are made of ties that connect the actors of the network. Ties are realized in practice through some activities (Podolny, 2001), and when these activities are repeated with a certain regularity over time and involve more than one individual, they may take the form of routines. In this book chapter, I reflect on the in-practice nature of networks—that is how networks work in the realm of action—adopting some of the insights coming from the organizational routines’ studies—and more in particular, the Routine Dynamics stream of literature—to shed new light on network dynamics.

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Some studies have tackled the issue of networks emergence, evolution and change (e.g. Chen et al., 2022; Clegg et al., 2016; Gulati, 1995; Gulati & Gargiulo, 1999; Zaheer & Soda, 2009), and others have called for departing from a static view and assuming a more dynamic understanding of how networks work in a longitudinal and processual perspective (Ahuja et al., 2007, 2012; Borgatti et al., 2014). A means of networks change is the (re)configuration of the ties of the network (Hernandez & Menon, 2021), in terms, for example, of their strength and weakness (Granovetter, 1973), their potentiality and their being latent (Mariotti & Delbridge, 2012). The actors of the network create (Padgett & Powell, 2012) and inherit new ties (Hernandez & Menon, 2018), pause and revitalize some established ones (Levin et al., 2011), or abandon others (Kleinbaum, 2018; Zhang & King, 2021).

Network ties are made of exchanges and activities that happen between two nodes of a network (Borgatti & Foster, 2003; Chen et al., 2022). When these exchanges and activities are repeated with a certain regularity, they can take the form of routines that play a crucial role in network persistence and change (Ahuja et al., 2012; Kim et al., 2006). Applying the insights coming from routines' studies can be therefore useful to understand networks changing dynamics. More specifically, the Routine Dynamics stream of literature explains how routines change over time (Feldman, 2000; Feldman et al., 2016, 2021; Feldman & Pentland, 2003) and focuses on the work of the agents who perform them (Feldman, 2000; Feldman & Pentland, 2003; LeBaron et al., 2016; Turner & Rindova, 2012). I discuss networks as based on routines, precisely adopting the Routine Dynamics perspective. In this way, I develop some reflections on the change and maintenance of network ties over time, and I elaborate on the notion of networks in practice or the fact that networks become concrete in the dynamics that happen at the level of the recurrent exchanges among the nodes of those networks.

This chapter is structured as follows. At first, I present some of the main aspects of the Routine Dynamics perspective, and summarize what organizational routines are and how they work according to it. Then, I contextualize these insights in network research. I conclude this book chapter elaborating on the potentiality of using the organizational

routines lens—and more in particular the Routine Dynamics perspective—to understand how networks work and suggesting some possible directions for future research.

2 Routine Dynamics: Change and Persistence in Organizational Routines

Organizational routines are ubiquitous in and among organizations and carry out different central roles (for a review: Becker, 2004). Among the others, they are means through which individuals, groups and organizations are able to coordinate each other to reach specific goals and they guarantee a certain level of stability.

Their relevance has attracted the interest of many researchers over years, who approached them from different points of view (Feldman et al., 2021). While some scholars mainly focused on the cognitive dimension of routines and their stability, the Routine Dynamics perspective concentrates on the practice dimension of organizational routines, and explains how they emerge, change and evolve over time (Feldman et al., 2016, 2021). More precisely, the Routine Dynamics perspective offers a lens through which capturing how routines endogenously change, meaning that this perspective focuses on the internal dynamism that occurs during routines performance, and that eventually makes routines what they are.

According to the Routine Dynamics approach, organizational routines are a specific type of practices (Feldman, 2021) that refer precisely to patterns of interaction that are recurrently enacted (Feldman & Pentland, 2003). They result from the continuous interplay between the participation of individuals in the routine—agency—and the routine structure (Dionysiou & Tsoukas, 2013; Feldman & Pentland, 2003). This interaction is represented by the ostensive-performative framework (Feldman & Pentland, 2003). The ostensive dimension of the routine is the routine in principle and collects all those features that form the very structure of the routine (Feldman & Pentland, 2003). The performative dimension

complements the ostensive one and refers to the routine in practice (Feldman & Pentland, 2003), or the fact that organizational routines are realized in the actual performance. The ostensive dimension guides the action of routines' participants; the performative one, instead, maintains and modifies the ostensive (Feldman & Pentland, 2003).

During the routine performance, the agents in charge of performing the routine have the opportunity to shape the routine structure altering it, or make it persistent over time (Feldman, 2000; Feldman & Pentland, 2003; LeBaron et al., 2016; Suarez & Montes, 2019; Turner & Rindova, 2012; Yamauchi & Hiramoto, 2016). Despite also non-human agents take part to the routine performance and affect how organizational routines develop over time (Bapuji et al., 2012; D'Adderio, 2011, 2014, 2021), in this book chapter I focus on human agents and, as a consequence, on human agency—that is “the temporally constructed engagement by actors of different structural environments—the temporal-relational contexts of action—which, through the interplay of habit, imagination, and judgment, both reproduces and transforms those structures in interactive response to the problems posed by changing historical situations” (Emirbayer & Mische, 1998, p. 970).

Agency is driven by individual and collective aspects. For instance, as far as it concerns the individual dimension, one of the drivers of the participation of agents in the routine is their memory (Argote & Guo, 2016; Cohen & Bacdayan, 1994; Miller et al., 2012, 2014). Individual memory stores the fundamental of routines, and more in particular the know-what, know-how and know-who—the procedural, declarative and transactive memory—(Argote & Guo, 2016; Cohen & Bacdayan, 1994; Miller et al., 2012, 2014). According to memory, agents are able to reproduce routines over time and across spaces (Miller et al., 2012). On the contrary, the ability of seeing new opportunities (e.g. Turner & Rindova, 2012) and exploit them makes performing agents those who are responsible of routines adaptation and change. For example, when the context where the routine is performed changes and it is not possible anymore to enact the routine as usual, instead of dropping out the routine, agents may exercise their ability to adapt it in a way that accommodate the new circumstances.

The dynamics of routines do not depend exclusively on the individuals' decisions and actions. Indeed, organizational routines are made of interdependent tasks that, consequently, connect agents (Feldman & Rafaeli, 2002). In this respect, organizational routines are different from individual habits. The latter mainly concern the individual and are performed by a single actor; organizational routines instead involve collectives. This means that during the routine performance agents may decide what to do together (e.g. Dittrich et al., 2016) and that the retention of a change in the routine performance depends not only on an individual but on the group of actors involved in it.

Among the multiple aspects on which the Routine Dynamics is based and sheds light on, in this book chapter, I mainly focus on the interaction between structure and agency to consider the fact that, while performing a certain structure, agents may change it.

3 Network Ties Through the Routine Dynamics Perspective

Organizational routines are recognized to affect networks and their dynamics: for example, Ahuja et al. (2012) suggest that ties “tend to persist or develop because of routines and norms or habits (for individuals) that develop in the context of an interacting set of entities” (p. 439). Moreover, routinization takes part in networks emergence (Ritter & Gemünden, 2003) and routines contribute to stabilizing and maintaining networks over time (Ahuja et al., 2012; Kim et al., 2006). Building on the fact that routines play a role in ties development, in this book chapter, I consider that the ties that constitute a network are based on organizational routines, and thus I apply the Routine Dynamics perspective to elaborate on ties change and persistence.

3.1 Key Concepts and Assumptions

Network ties establish connections between pairs of actors (Borgatti & Foster, 2003, p. 992)—whether actors are individuals, groups or organizations (Borgatti & Foster, 2003). With the nodes and the patterns that

result from ties, ties are one of the primitives of the network architecture (Ahuja et al., 2012). Despite through ties, some content flows (Ahuja et al., 2012)—for example, knowledge-, in this book chapter, I do not focus on *what* flows—the content—but on *how* what flows flows.

Between the nodes connected by a tie, some interactions occur that the literature calls relational events (Butts, 2008; Leenders et al., 2016; Schecter & Quintane, 2021). Relational events “consist of relational behaviors (e.g., A sends B an email) and transactions (e.g., A buys goods from B) [...] and can be thought of as things a node *does* with another node (e.g., goes to a movie with) rather than something it *is* with another node (e.g., a friend)” (Chen et al., 2022, p. 1609). While relational events can have an ephemeral nature (Chen et al., 2022), I assume that some relational behaviours and transactions between a pair of nodes can be repeated with a certain regularity over time so that they take the form of organizational routines. In this respect, Zollo et al. (2002) focus on the relationship between two organizations and introduce the concept of interorganizational routines to define the “stable patterns of interactions among two firms developed and refined in the course of repeated collaboration” (Zollo et al., 2002, p. 701).

With these understandings, I apply some of the key insights of the Routine Dynamics perspective on network studies, and I reflect on the evolution and persistence of the ties of a network.

3.2 Looking at How Ties Develop and Persist Over Time from a Routine Dynamics Perspective

As illustrated above, the Routine Dynamics perspective provides an understanding of how organizational routines work at a micro level, and thus explains the endogenous dynamics that make organizational routines change and persist over time. This stream of research can thus provide some in-depth insights about the dynamism of the ties of a network over time.

Changing the Status of a Tie: Adaptations of Coordination

Not all the ties of a network are active, and they do not stay always active over time. A dormant tie is defined “as a relationship between two individuals who have not communicated with each other for a long time” (Levin et al., 2011, p. 923). Thus, from active, ties can turn to be inactive, but, eventually, they can be reactivated (Levin et al., 2011). A similar mechanism occurs at the organizational level (Levin et al., 2011; Mariotti & Delbridge, 2012): latent ties are “established relationships that are currently inactive in terms of exchange” (Mariotti & Delbridge, 2012, p. 514), and, when necessary, can be made active again (Mariotti & Delbridge, 2012). These changes from a status—for example, being a latent tie—to another—for example, being an active tie—are hampered by different factors (e.g. Walter et al., 2015).

According to the Routine Dynamics perspective, the context where the tie—and the related routines—occurs is a fundamental variable for routines’ change and persistence. Indeed, routines are extremely sensitive to the context in which they are performed (Christianson et al., 2009; Howard-Grenville, 2005; Howard-Grenville & Lodge, 2021; Suarez & Montes, 2019; Turner & Fern, 2012), and, over time, the context changes. This may happen for routine’s performances that are close in time, because the context where the routine occurs is never the same twice—this idea is at the core of the concept of the (n)ever-changing world (Birnholtz et al., 2007; B.T. Pentland et al., 2011). The context may change also and especially when a routine is not performed for a period of time and should be reactivated. Therefore, the transformation of the context may be what makes the enactment of routines after some time of inactivity effortful and complex. Reactivating the routines that realize a tie in practice could thus require processes of adaptation. Routines’ participants may introduce some novelty and alternative ways through which performing routines again, and they may need some time—that is some performances—to find a new equilibrium of coordination.

The Routine Dynamics perspective accounts also for the fact that agents may change too. That actors of a network act accordingly to the

experience they have collected about the tie over time (Dahlander & McFarland, 2013; Kleinbaum, 2018) and their personality's traits (Brass et al., 2004) is a well-known phenomenon. The Routine Dynamics perspective considers the evolving character of agents' experience and intentionality. Agents employ their experience when performing routines (Espedal, 2006; Turner & Fern, 2012), meaning that they use what they learnt from the participation in that routine and in other routines, and in this way, they accumulate new experience. Accordingly, agents may be willing to perform routines in new ways that accommodate their new knowledge and understanding. Agents may also change the intentions according to which they perform a certain routine (Dittrich & Seidl, 2018). As a consequence, there could be some conflicting goals among routines' participants, who need to find a new equilibrium in order to be able to perform the routine (Salvato & Rerup, 2017).

In sum, what the Routine Dynamics perspective allows to understand is that the reactivation of a tie—that is when a tie passes from being inactive to be active—is a complex process that requires actors' time and effort to find an equilibrium that accommodates the new circumstances. Routines are truces, and reaching the truce is an accomplishment more than a precondition (D'Adderio & Safavi, 2021; Zbaracki & Bergen, 2010). In fact, the coordination that governs them is ongoing and the result of every routine performance (LeBaron et al., 2016). Looking at the reactivation of a tie from a Routine Dynamics lens highlights the fact that the actors of a tie may encounter some coordination issues and challenges that slow down the achievement of the results that are expected to be reached once a tie is decided to be reactivated. While reactivating a tie with the objective of one-shot and frugal interaction can be easier, reactivating a tie with the objective of having frequent and recurrent exchanges could be complex and the result could not be straightforwardly a success.

Maintaining Ties: A Challenge More Than a Piece of Cake

The stability of ties over time is part of the debate on ties maintenance (Levin et al., 2011; Levin & Walter, 2018; Walsh et al., 2018). The literature discusses whether it is advantageous or not to maintain a tie over

time, and provides two opposing results, as Levin and Walter (2018) identify. While, assuming an activity-based perspective, maintaining ties active is convenient, assuming a memory-based perspective, maintaining ties is not worthy, because memory can compensate the absence of an active tie (Levin & Walter, 2018). What seems to be a common point of these two alternative perspectives is the fact that maintaining a tie can be time consuming and effortful (Levin & Walter, 2018). In this respect, in network research, routines are recognized to serve as means through which ties persist over time, because they are understood to be sources of inertia (Ahuja et al., 2012, p. 440).

The Routine Dynamics literature provides some insights exactly in this direction, problematizing the maintenance of recurrent patterns of interaction over time. Contrary to common understandings (Cohen, 2007), it should not be taken for granted that organizational routines stay the same over time (Schultz, 2008). By definition, routines are performed with a certain level of regularity, but they may also evolve and modify endogenously (Feldman, 2000; Feldman & Pentland, 2003), and even decay (Anand et al., 2012). This happens because of the participation of human agents in the routine performance.

Agents may see the opportunity to perform the routine in a different way (Turner & Rindova, 2012), or develop new understandings through which performing the routine (Dittrich & Seidl, 2018), or capture the changes in the external context and thus adapt the routine accordingly (Suarez & Montes, 2019). Indeed, agents are responsible of patterning work (Danner-Schröder & Geiger, 2016; Feldman et al., 2021; Goh & Pentland, 2019)—the creation of new paths and the dissolution of old ones (Goh & Pentland, 2019). As a matter of fact, routines may derail, and their stability may be compromised. Some factors counteract the dynamics of change and contribute to maintaining routines as they are—for example, agents' memory play this role (Schultz, 2008). However, for maintaining routines on track some effort is required.

The Routine Dynamics perspective thus reinforces the idea that maintaining a tie over time may be costly. It suggests that the cost of maintenance can imply the effort of controlling if the routines that constitute the tie stay the same over time, and, if necessary, correcting the course of actions of those routines. The Routine Dynamics perspective

problematizes the stability of recurrent patterns of interaction. Routines can assume new forms given the work of the agents who perform them. If, on some occasions, these new forms accommodate the changing contextual conditions with the result of survive the tie, in other occasions the work of agents can make the tie derail.

4 Conclusion

In this book chapter, I conceive the ties of a network as formed by routines, and thus, I apply the Routine Dynamics perspective—a stream of research that focuses on the practice dimension of organizational routines and aims at understanding how routines emerge, change and evolve over time—to shed new light on the dynamics of ties change and persistence over time.

This perspective allows to overcome three critical aspects that usually characterize network research. At first, the Routine Dynamics perspective puts emphasis on the in-practice nature of networks that is often taken for granted in network studies. Since some years, network research has incorporated the process perspective (Ahuja et al., 2012) and, in fact, different studies explore networks emergence, change, failure and dissolution. Despite the usefulness of looking at networks in process terms, there is still a dimension of networks that remains in the shadow: their realization in the recurrent exchanges among the nodes of the network. The Routine Dynamics perspective exactly provides a lens through which capturing and understanding this aspect. It is in the repeated activities among actors—the routines that make ties effective in practice—that there is a source of change and evolution of networks. On this basis, I develop the idea of network in-practice that I define as the realization of the network in the realm of action through the recurrent exchanges among the nodes of the network. So doing, I address the debate of the microfoundations of network change or “the basic factors that drive or shape the formation, persistence, dissolution, and content of ties in the network” (Ahuja et al., 2012, p. 437), and I suggest looking at the internal dynamics of the routines that occur among the nodes of the network to understand how networks endogenously change.

Indeed, the second point concerns the fact that the Routine Dynamics perspective brings to the forefront agency—the engagement of human actors in organizational activities (Emirbayer & Mische, 1998). Human agency plays a significant role for networks evolution (for a recent review: Tasselli & Kilduff, 2021), but the majority of studies still treat it with a certain degree of shallowness (Kilduff & Brass, 2010; Tasselli et al., 2015). This is problematic because certain aspects of network dynamics remain uncovered and taken for granted, creating some limitations in our understanding of how networks evolve over time. The debate on agency and structure permeates management discourses, and it is central in organizational routines studies (Feldman & Pentland, 2003), where the relation between structure and agency is conceived as a duality (Ansell et al., 2015; Farjoun, 2010), meaning that structure and agency are the two faces of the same coin, and that, at the same time, the structure shapes agency, and agency shapes the structure. By adopting the Routine Dynamics perspective, it is possible to conceive networks in dual terms: their structure orients the work of agents, and the latter adapt and change the structure of the network. Networks are thus “spaces” made of the constant interaction between agency and structure, and this interaction determines the evolution of networks over time.

Finally, the Routine Dynamics perspective allows to overcome the single party focus that commonly distinguishes network studies (Lumineau & Oliveira, 2018) and takes into account the asymmetry that the tie inevitably implies—given that it connects two actors. In fact, organizational routines are the result of a collective endeavour, where the individual does not act in a vacuum but always in relation with the other agents involved in the routine performance. What the other routine’s participants did in the past and what they do in the present performance of the routine matter and should be taken into account in understanding of how things work as they do.

To conclude, in this book chapter, I suggest that the Routine Dynamics perspective is a promising lens through which exploring networks dynamics. It can be used as an analytical tool to drive the investigation of those studies that aim at exploring how networks work in the realm of action, that is, in practice. As reported in Chap. 2 of this book, in network research, qualitative studies are increasing in the last years. This insight

suggests that there is an increasing interest in better understanding how networks work, and the Routine Dynamics lens can be a valuable support to make sense of the reality that is observed. Future research could work in this direction.

Despite this book chapter aims at contributing to network research using the Routine Dynamics lens to enlighten some aspects of network dynamics, I conclude with a final remark that concerns the organizational routines literature, because the latter may benefit from a more in-depth consideration of the insights coming from network studies. In the organizational routine literature, the concept of network mainly appears in three forms. At first, the network is a way to represent organizational routines. With the aim of explaining the interaction between organizations and technology, Pentland and Feldman (2007) introduce the idea of narrative network, “a method for representing and visualizing patterns of technology in use” (p. 787). The nodes of the narrative network are the narrative fragment, where “Narrative fragments consist of at least two actants and some kind of action that occurs with them or between them” (Brian T. Pentland & Feldman, 2007, p. 788)—actants can be both human and non-human. The ties of the narrative network are narratives—where narratives are sequences of events with certain aims (Brian T. Pentland & Feldman, 2007, p. 788). As a method, the narrative network orients the attention of the research on the following aspects: (i) there are different points of view from which telling the story, (ii) within the network, there are some stories that go on in parallel, (iii) each of these stories can unfold in different possible ways, and (iv) there are other stories that intersect (Brian T. Pentland & Feldman, 2007). The narrative network is thus useful to “summarize relations between actions in observed performances of a process” (Brian T. Pentland et al., 2020, p. 3) and provides a representation of organizational routines as multiplicities. In fact, every routine is not a single path, but a space of possible paths (Brian T. Pentland et al., 2020; Brian T. Pentland & Rueter, 1994), and the narrative network supports the representation of routines as multiplicities. Secondly, organizational routines studies use networks as the implicit context of action where organizational routines occur. This happens at the intraorganizational level, where organizational routines do

not operate in isolation, but in connection with other routines, so that they form clusters (Kremser & Schreyögg, 2016) and ecologies (Sele & Grand, 2016), and at the interorganizational level, because routines develop also outside the organizational boundaries, and they become the means through which alliances (Zollo et al., 2002) and merger and acquisitions (Finkelstein & Haleblian, 2002; Safavi, 2021; Safavi & Omidvar, 2016) realize. At third, networks are the outcome of organizational routines work (Feldman & Rafaeli, 2002). Feldman and Rafaeli (2002) show that organizational routines establish connections—and thus networks—among the routines participants who can thus socialize and develop shared understandings about organizational routines and the overall organization. Despite, the idea of networks is not unfamiliar to organizational routines studies, it is still on the background of the reasoning, and its potentialities are still partially—or even scarcely—exploited. Future research on organizational routines may draw more from the contemporary studies of network to advance the understanding of how organizational routines operate systemically.

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Entrepreneurship as Networking? Theoretical Insights from the Historical Literature

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1 Introduction

The dominant focus on individuals as discoverers or creators of opportunities in the literature on entrepreneurship has been convincingly questioned as unrealistic (Davidsson, 2015) and isolating agency from its context (Garud et al., 2014). Research on the interactive aspects of entrepreneurship was however undertaken separately from the strategic and the sociological point of view, respectively highlighting the benefits of establishing relationships with stakeholders, and the effects of an actor's relational position on entrepreneurial behaviour and attitudes. An integrative view has recently been suggested by Elfring et al. (2021), starting from a social capital approach to highlight the centrality of networking in entrepreneurship, up to suggest the identification of entrepreneurial action and networking.

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Such an interpretation of *entrepreneurship as networking* implies that networking is not just an enabler of entrepreneurship, but it constitutes the essence of the “key entrepreneurial processes of opportunity development, resource acquisition, and gaining legitimacy” (Elfring et al., 2021, p. 161). Consequently, in a Schumpeterian perspective where entrepreneurs are agents of change, if entrepreneurs are brokers, change itself can be interpreted as the result of new connections.

The new research agenda that such an identification opens up includes a strong focus on the variance of contexts, together with an attention to evolutionary and path-dependent processual dynamics. Different theoretical approaches can be useful to deal with these questions, from the literature on institutional logics and institutional change (Seo & Creed, 2002; Thornton et al., 2012) to the debate on the exploitative or coordinating role of brokerage (Burt, 1992, 2004; Obstfeld, 2005, 2018). However, understanding entrepreneurship as networking implies an inescapable *historical perspective*, which relates on the one hand to the elusive nature of entrepreneurial opportunities and to their radical uncertainty (Dimov, 2011), and on the other one to the multiple temporalities of network dynamics (Ahuja et al., 2012). In other words, a retrospective approach is needed to combine, on different timescales, our hindsight on the outcomes of past actions and the interpretive frame of their authors at the time, this way shedding light on the emerging, unexpected results of entrepreneurial networking. Considering the heterogeneity of ends in historical perspective avoids the contradictions of an individualistic strategic approach to entrepreneurial opportunities and provides a contingent, non-deterministic interpretation of network evolution as the inherent result of entrepreneurial actions.

Following the invitation coming from Elfring et al. (2021, pp. 161–162) to experiment with multiple perspectives on entrepreneurship as networking, I propose here an exploratory review of the historical literature dealing with entrepreneurship and networking to highlight the potential theoretical contributions deriving from the engagement of different scholarly perspectives. The considered research items include mostly articles published in relevant international journals, but also some (reviewed) books and some chapters. Together with the usual statistical analyses, a study of co-citation networks was performed here, highlighting the extreme fragmentation of this literature.

The subsequent discussion focuses on the range and the variety of the interpretive models of entrepreneurship, which are used in this composite literature in connection to social networks. An assessment of their theoretical implications to social scientific debates on the same issue suggests that the main contribution of such studies concerns network brokers and the paradoxical complementarity between their exploitation of network holes and their role in filling them (Obstfeld, 2005, 2018), shedding new light on the different temporality inherent in the ambivalence of the entrepreneur as a monopolist and a change maker.

2 Entrepreneurs as Brokers: An Historical Approach

The interpretation of the entrepreneur as a broker has been already suggested by the historical economist Georg Simmel and formalised more recently by Ronald Burt (1992), who later made it explicitly the subject of his inquiry (Burt, 2004). However, such a thread maintains a strategic perspective, mostly focusing on the role of the broker as an entrepreneur who exploits the presence of structural holes in a social network by taking advantage from being the only one to be able to bridge them (*tertium gaudens*, in Obstfeld's 2005 definition). The limits of this perspective have been in part highlighted by David Obstfeld (2005). His research showed the possible role that brokers have in putting in direct connection other complementary actors, apparently giving up their advantage to make it possible the realisation of otherwise impossible projects (*tertium iugens*). The availability and the actual use of both approaches by brokering actors have been emphasised in subsequent research contributions. More recently, the same Obstfeld (2018) has pointed at the different kind of engagement required by what he identifies as three distinct brokerage activities: the exploitative *tertium gaudens*, the simple conduit role of a broker passing forward information, and the role of translator performed by a proper *tertium iugens* who makes use of her "relational astuteness" to mobilise and coordinate different audiences towards projects implying innovation defined in terms of change in the social context.

From this perspective on entrepreneurship as networking, some questions emerge, which concern the definition of innovation and entrepreneurship.

First of all, what about the role of disruption, which is essential to the Schumpeterian definition of innovation? New connections may imply the disruption of previous vantage positions, but the issue is worth a more extensive consideration. In fact, disruptive effects may be rather an unintended effect of actions exerted on complex networks. This point raises the question if brokerage in all its forms is a strategic or an emerging function of some actors? The question here affects not only the structural or agentic quality of brokers but also the intentional or unintentional results of their activity.

Such issues inherently concern networks as complex systems, which means systems producing outcomes that cannot be forecasted, neither certainly planned in terms of their components or from their individual interactions (Bar-Yam, 2002). A main characteristic of such systems is their historical dependence on a sequence of irreversible and unexpected events, which may trigger radical change (Buchanan, 2000). An explanation of such unexpected events can be attempted by means of a constant swing relaying, on the one hand, the historian's hindsight of outcomes, the ex-post knowledge of "how it all turned out", and, on the other one, the standpoint of agents and what they knew about their time, the future they imagined, their strategies and their projects, which sometimes may appear unrealistic. A historical approach to network agency, allowing the retrospective consideration of past events (Decker & Wadhvani, 2017), allows to identify unintended effects, to discriminate the different brokerage functions and to highlight the changes in the network structure that brokering activities imply in the long term.

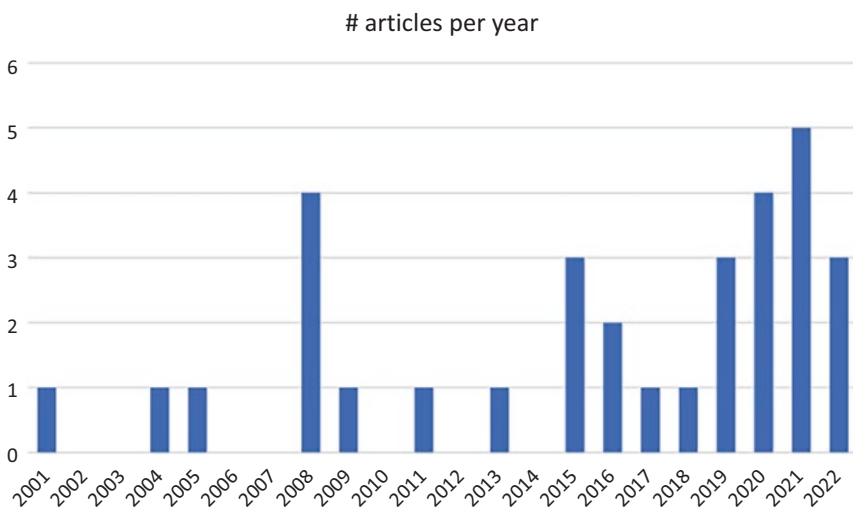
3 Reviewing a Fragmented Body of Literature

The approach adopted here aims at highlighting the potential theoretical contribution coming from a diverse literature, which makes only distant reference to the managerial literature on entrepreneurship as networking

but offers precious insights on the issue by means of an independent process of theory building. The choice to focus on the subject area Arts and Humanities responds to this purpose. The dominance of historical approaches in such a broader field was expected but appears even stronger as far as issues concerning entrepreneurship and networking are concerned.

The literature review was performed using the Scopus database and selecting materials in the Arts and Humanities subject field, which included in the title and in the abstract both the words “network” and “entrepreneur*” (where * stands for all possible suffixes). The results were a relatively small number of articles (27), some reviews of books (4) and a book chapter (1) (Plehwe, 2021), for a total of 32 items. If Arts and Humanities was always one of the subject fields, in 22 cases the journal was also included in the Social Sciences field; in 8 cases in Business, Management and Accounting; and in 3 cases in Economics, Econometrics and Finance. Many other fields, from Environmental Sciences to Agricultural and Biological Sciences, have single entries.

The different outlets publishing this research are 18, so publication is quite scattered. The main journal, with four entries, is *Business History*, followed by *Sage Open* (3) and the *Journal of Ethnic and Migration Studies* (2).



The timing of publications shows a quite scattered distribution starting from Zalc (2001), with a first peak of four contributions in 2008, a second with three in 2015 and two in 2016, and a more stable frequency between three and five articles per year from 2019 up to 2022. Half of the articles were published from 2018 onwards: this highlights a growing interest on the issue of networks and entrepreneurship in historical studies (as included in Arts and Humanities), which only in 2001 begins to appear explicitly in the title and abstract of papers. Studies on the same subject in Business, Management and Accounting start instead in the Scopus database from 1985 and display a steep growth in number from 2003 onwards.

However, such an interest remains apparently limited to references to the general literature on the subject, with almost no citations among the selected articles. These authors appear not to be engaged in a scientific conversation among them, aside from one connection deriving from the fact that the same persons were authors in two articles and cited themselves. These results of the analysis of reciprocal citations may depend on the limited coverage of historical literature in Scopus, yet it is evident that most of the articles here considered make reference to different scholarly debates, with a few references to the general literature on entrepreneurial networks.

These findings confirm that the main characteristic of the (historical) literature concerning entrepreneurship as networking is its fragmentation, with scattered attempts at integration by single scholars. This implies, on the one hand, the redundancy of some concepts, but also some lack of communication between different approaches. What emerges as the common trait is an interpretation of entrepreneurship as the ability to connect and to recognise the connection opportunity, rather than to do something in itself—leading, managing or creating: the idea of new network connections as an engine of change is a concept that emerges more explicitly in some specific fields, from international relations (Goddard, 2009) to event and arts management (Booth, 2015; Guo, 2022), but that is implicit in many other areas of research.

The main common reference for many (but not for all) studies is the sociological approach to the social network analysis focusing on strong and weak ties (Granovetter, 1973), structural holes and brokerage (Burt,

1992), and the measure of embeddedness (Uzzi, 1996), together with references to the neo-Schumpeterian approach of Casson et al. (2010).

Such a literature suggests a distinct approach from the debate on business networks as a determinant of entrepreneurship (Aldrich & Zimmer, 1986), which inspired the debate on multiple institutional logics and the ability of embedded actors to exploit connections and contradictions among them to open the way to new combinations and then to change (Seo & Creed, 2002; Thornton et al., 2012).

Developments in actor-network theory (Latour, 2005) may offer some methodological support to this view, but the theoretical insights deriving from this body of research were not integrated (Vernet, 2021) and only sparsely discussed in this thread. However, they inform many historical and anthropological studies that refer to a multiple repertoire of theoretical approaches, taking inspiration from the questions that microhistory posed on the relationship between individuals and the manifold contexts they are embedded in and contribute to change (Ginzburg et al., 1993; see for example Knight, 2018; Kaya, 2020).

4 Using Historical Research to Highlight the Diverse Temporality of Networking

Taking closely into exam the body of literature here considered, a specific set of themes in evolution emerges, despite the lack of mutual references. If corporate (Gumerov et al., 2015) and network governance (López-Morell & O’Kean, 2008; McDade, 2011; Sarwar et al., 2021; Somkaun et al., 2021), along with sustainable (Migliore et al., 2015; Jiatong et al., 2021) and digital entrepreneurship (Santisteban, 2019; Mendick et al., 2021) appear among the main subjects, diaspora studies both in historical (Caglioti, 2008; Rubio-Mondejar & Garrues-Irurzun, 2022) and present-day contexts (Irurzun et al., 2013; Lo, 2016; Baubekeur, 2016; Jan, 2017; Liu et al., 2020) include many of the items of research here considered. Among them, some articles display a strong focus on family issues as relevant in network formation, in particular in the context of diaspora communities (Irurzun et al., 2013; Lo, 2016). Such a focus shifts more and more to gender issues since 2019, highlighting the

emancipatory role for women entrepreneurs of some kinds of network connections (Jaafar & Alwazni, 2019; Savall et al., 2020) rather than others (Rubio-Mondejar & Garrues-Irurzun, 2022).

Despite the lack of direct citations, this argument well relates to Obstfeld's (2005, 2018) distinction between the different functions that brokers can exert by exploiting their position (*tertium gaudens*) rather than favouring the filling of network holes by means of new connections between other nodes (*tertium jungens*). On this issue, three main considerations emerge from this fragmented literature, offering important insights into the actual working of brokering dynamics in historical context.

The first point concerns the fact that the *tertium jungens* entrepreneur appears less performing than the *tertium gaudens*, or the classical broker who exploits her position. Network density results in fact not correlated with the growth of entrepreneurial firms (Peng & Li, 2022), and the "psychological adaptation" deriving from intense networking has a negative effect on the entrepreneurial skills of businessmen exposed to foreign culture (Abodohoui et al., 2020). Such an outcome is related to the idea that closely knit networks resulting from *jungens* activity work better in situations of institutional deficit, where social capital can exert a substitutive function (Gómez-Galvarriato, 2008).

Second, on the other hand, the *tertium gaudens* model of networking clearly appears to exclude and limit access to entrepreneurship, discriminating socially weaker actors, as women or lower classes, using them as tools (Rubio-Mondejar & Garrues-Irurzun, 2022) and reinforcing existing hierarchies and relationships of power (Lo, 2016). This is true both for pre-modern societies and for present-day digital society, where the geek entrepreneur reaffirms masculine roles (Mendick et al., 2021).

The exclusion of socially discriminated actors from access to entrepreneurship highlights a main issue that *gaudens* brokering entrepreneurship poses: the single entrepreneur performs better at the cost of a reduction of entrepreneurial possibilities. The *jungens* brokering entrepreneurship instead creates social capital not only in terms of direct connections but also by making the whole society more densely connected and viable (Rusinovic, 2008). The lack of correlation with the growth of entrepreneurial firms (Peng & Li, 2022) does not imply that the *jungens* attitude

is ineffective at societal level. In fact, as Vandekerckhove and Dentchev (2005, p. 221) demonstrate, *gaudens* “entrepreneurs will tend to take a central position in their stakeholder environments and thus fail to adapt to the complexity of stakeholder relationships in their entrepreneurial activity”: this, in turn, will inhibit their ability to “use the complexity of stakeholder relationships in order to go beyond their cognitive limitations and thus facilitate the discovery of new opportunities”. On the contrary, altruistic social networking may be chosen as a behaviour that enhances the serendipitous possibility to meet unexpected opportunities (Dew, 2009, p. 748).

The suggestion emerging from these considerations is the importance of the cognitive advantages related to “psychological adaptation” (Abodohoui et al., 2020), which may not appear immediately evident, but emerge in the medium and long term from the related ability to grasp entrepreneurial opportunities (Rungtornkiet & Sutduean, 2019) that remain invisible to the *gaudens* entrepreneur who maximises her positional advantages.

Such considerations shed light on the need to discern the different temporalities that respectively characterise the *gaudens* and the *jungens* approach to brokerage, entrepreneurship and innovation. What distinguishes the two approaches is, respectively, the consideration of performance in a context of relative stability, and the potential evolution triggered by serendipitous but crucial knowledge opportunities (as shown in Parsons & Rose, 2004). If the most evident distinction is between a short- and long-term perspective, focusing on the *temporality* of the agents implies an attention to the different way they *act in the present* connecting their *interpretation of the past* and their *vision of the future* (Reinecke et al., 2020). In this respect, relevant distinctions do not only include the relationship with distant or close events, but also the continuity or discontinuity established between the interpreted past and the imagined future, which is directly related to an adaptive or creative entrepreneurial attitude.

The main contribution coming from the fragmented literature aggregating historical studies on entrepreneurship and networking to the debate on entrepreneurship *as* networking is then the discovery that the *temporal perspectives* underpinning network agency may display relevant

variations, determining completely different attitudes, preferences and purposes about the choice of the connections to be actualised. Such a distinction makes it possible not only to assess the pertinence of different measures of network performance, depending on the relevant time frame, but also to introduce an important qualification to the classification of networking entrepreneurs proposed by Obstfeld (2018), that is, the different temporal orientation of *gaudens*, conduit and *jungens* brokers. Such a temporal qualification of networking entrepreneurship may be related to the distinction between routine-based and non-routine-based contexts proposed by the same author but sets it in the wider context of a situated temporal view (as suggested by Hernes & Schultz, 2020).

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Correction to: How Do Personal Preferences Influence the Flow Dynamics in Networks?

Rosario Maggistro and Raffaele Pesenti

Correction to:

Chapter 6 in: A. Moretti, L. Balzarin (eds.), *New Perspectives in Network Studies*, https://doi.org/10.1007/978-3-031-22083-8_6

The original version of this chapter incorrectly stated the mathematic symbols of equations.

The chapter has been updated with the correct equations as below:

1. In formula (12) the function ϕ_e depends on the sum of ρ , then write $\phi_e (\sum \dots)$ as in formula (4).
2. In the formula without a number under (12) it was asked to reduce the curly brace that contained the 3 formulas. Instead, they left the same dimension of the parenthesis and removed the 3 formulas inside it, but now, however, in the 2nd and 3rd expressions the 'e' is under the p, whereas it should be its subscript: p_e .

The updated original version for this chapter can be found at https://doi.org/10.1007/978-3-031-22083-8_6

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3. The quantity α for the summation in the final part of formula (4), has become smaller (as if to represent a subscript and not a product for the indicator function χ). The subscript j of the last e is now at the same level, and the integral sign is bold without anyone asking for it.
4. In the formula without a number between (6) and (7), in the denominator the \hat{p} was a superscript for the J (as well as in the numerator), while now it is at the same level (as was a product).

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