Unleashing the potential of relational research: A meta-analysis of network studies in human geography

Johannes Glückler and Robert Panitz
Ruprecht Karls Universität Heidelberg, Germany

Abstract
Social network analysis has become a popular methodology in human geography. This article develops three propositions – connectivity, contextuality, and reflexivity – for relational analysis to overcome the dualism between universalist network science on the one hand and idiosyncratic network stories on the other. Building on a detailed meta-analysis of over 300 network studies published between 1990 and 2018, we offer a sympathetic critique of the actual use of network methods in human geography. To unleash further potential of network research, we propose several research strategies for more inclusive relational analysis, including informed pre-specification, triangulation, and communicative validation.

Keywords
meta-analysis, mixed-methods, network theory, relational geography, social network analysis, triangulation

I Introduction
In human geography, relational thinking and formal network analysis have developed almost independently of each other. Formal network geometry was already established in the 1960s as a methodological approach to design optimal infrastructure networks and calculate the shortest routes in logistics and transport (Haggett and Chorley, 1969). However, in the 1980s, formal relational analysis lost significance as human geographers shifted perspective toward conceptual relational thinking, which placed social actors and economic action above the characteristics of physical space. It was not until the end of the 1990s that formal analysis of social networks was once again introduced into the field, mainly as an import from economic sociology (Grabher, 2006). Here, scholars conceived social structure as network structure (Crossley, 2020; Emirbayer and Goodwin, 1994) and called for the use of relational methods to advance relational thinking. Coincidently, an analysis of journal publications in the field of economic geography illustrated that in the 20 years, between 1990 and 2010, articles on ‘networks’ had become disproportionately popular (Glückler, 2013). However, and much against the expectations of Smith (1980), the number of articles that addressed ‘network theory’ and ‘network analysis’ continued to remain very low until the turn of the first decade of the 21st century.

Over the last decade, social network analysis has become more widely used in empirical...
studies of human geography. On the one hand, digital technology has eased the collection and storage of social data, making big data ever more accessible for research. On the other hand, network scientists have continued to broaden the pool of methods by developing new measures, analytical procedures, and software packages to make network analysis usable for empirical researchers (see, for instance, the 2016 special issue in *Journal of Economic Geography*). The proliferation of data, methods, and tools, however, has not only enriched research practice, but it also raises questions about the limits of network analysis, its appropriate use, and the validity of findings obtained from it.

We have seen relational thinking flourishing as a diverse field of theoretical advance that has evolved along various lines of thought, including, among others, actor–network theory, cultural geographies of economies, practice theory, social network theory, and relational economic geography. Relational thinking refers to an understanding of social phenomena as being constituted by social interactions that are situated in a structure of relations and contextual meaning. Relational geography has evolved around the nexus between social networks and space and the interdependent association between them. Despite the variation of conceptual approaches to relational thinking in human geography (M Jones, 2009), the common denominator is an underlying belief that social structure and the qualities of social relations matter in explanations of the geographies of societal phenomena. Ettlinger (2003), for instance, has emphasized the interdependency between the role of space in forming social relations and, inversely, the role of social networks in shaping economic geographies. Consequently, human geographers have looked at the mutuality of space and networks from different perspectives (Glückler, 2013): One stream of research has examined how geography affects the formation and change of networks. Locational proximity (Boschma, 2005) and local externalities of regional clusters have been shown to drive specialization and divisions of labor (Turkina et al., 2016), exchanges of information and the creation of innovation (Bathelt et al., 2004; Owen-Smith and Powell, 2004; Storper and Venables, 2004), as well as the creation of new network linkages (Glückler, 2007) within and between local and global scales. Apart from the impact of permanent proximity, research on temporary proximity (Torre and Rallet, 2005) has shown how gatherings at physical places conduce the configuring of new or the rewiring of existing fields and networks (Asheim, 2002; Bathelt et al., 2014; Crossley and Ozturk, 2019; Panitz and Glückler, 2017; Power and Jansson, 2008). Conversely, another stream of research has examined how social networks actually shape places and space (Crossley, 2020). Here, the social embeddedness and dynamics of networks (Coe, 2000; Hess, 2004) has been conceived as driving change in regional economies, for example, by means of inclusive institutions and their corresponding relational infrastructure (Storper et al., 2015).

In the light of human geographers’ growing interest in phenomena as complex as creativity, knowledge, innovation, resilience, governance, and institutions, we argue that theorizing and analyzing social networks requires a solid understanding of the actors, the relations, and the context in which actors weave and rewire their relations. Now, with the rising prominence of network analysis in human geography, we are interested in exploring how relational analysis can enhance relational geography. Our concern resonates with current calls for better methods in geography (Bathelt and Li, 2020). Although the foundations of relational thinking and its association with network analysis have been widely discussed (Grabher, 2006; A Jones, 2014; M Jones, 2009; Malpas, 2012), we do not yet know if relational analysis in human geography has contributed to building relational theories in geography. Hence, rather than discussing the theory of relational geography,
we focus on social networks as relational analysis. By relational analysis, we refer to those methods that observe social relations or interactions by using existing or collecting original data in small or large numbers, including participant observation, interviews, surveys, as well as formal and qualitative analytical techniques such as ethnography, hermeneutics, or social network analysis.

In this article, we revisit the use of network analysis in almost three decades of research in human geography and make propositions on how relational analysis may unleash its full potential to enable and support relational thinking and relational theory. Concretely, we propose to place social network analysis within more comprehensive research designs that include qualitative and formal methods and that work together to meet essential criteria of relational research. Social network analysis is sensitive to the quality of relational information, to missing data in the sample, and to the choice of measures and analytical procedures. Therefore, more inclusive methodologies help to capture meaningful data on social structure, to grasp the contextuality of their constitution, and to respect limits to the generalizability of the observed phenomenon. Although the call for mixing methods is not new to the world, the meta-analysis of network studies presented in this article documents its rare use.

In what follows, we aim to assess how methods of social network analysis have been actually used in human geography and to what extent these uses have realized the potential for relational thinking in geography. To assess this potential, we first conceptualize three criteria to be met by a relational methodology (section 2) before we conduct a detailed meta-analysis of over 300 articles in the major journals of human geography that have used methods of social network analysis in the period between 1990 and 2018. Based on this meta-analysis, we illustrate that network research in human geography has been characterized by the analysis of often nonsocial relations between nonsocial actors, by a biased view on nodes rather than the networks as a whole, and by problems of construct validity and meaning ascription in single-method research designs (section 3). Building on this experience, we offer a sympathetic reflection and elaborate on research strategies for more inclusive relational analysis in section 4, which reconciles the tension between relational form (structure) and relational content (meaning). Section 5 draws some conclusions regarding the potential and limits of relational analysis.

II Relational Thinking: Connectivity, Contextuality, Reflexivity

Despite the popularity of relational thinking in our field, debate about appropriate methodologies, ways to capture empirical observations in their relational and spatial context, and if methods meet the requirements of a relational perspective have been very silent to date. Therefore, we first discuss key characteristics of relational thinking and infer three criteria for relational analysis to meet the requirements for relational theory building. Concretely, we suggest that empirical projects of relational geography should to overcome the fallacies of categorialism, formalism, and neutralism to unleash the full potential of relational analysis.

I Beyond Categorialism: Connectivity and Relational Thinking

Specialization and exchange, the differentiation of social roles, and social divisions of labor characterize social and economic life. Organizations and the people who work there pursue different goals, take on different tasks, and relate to other organizations through exchanges in information, capital, and other resources and through relations, such as cooperation, rivalry, or power relations. The multitude of actors and
the relationships that exist between them are
the building blocks of social networks. Some
traditional approaches have focused on net-
works and relations without realizing the full
value of the potential of connectivity. Two con-
ventional research designs can be highlighted as
examples:

Monadic Networks. One traditional research
design treats networks as a unitary entity. Typi-
cally, it draws a random sample of networks
(typically: corporations and organizations) and
collects information only from its representative
manager who, then, characterizes the respective
network as a whole. Sturgeon (2003), for exam-
ple, built on interviews with managers from lead
firms to interpret the organizational networks of
the Silicon Valley as a modular production net-
work. Although such research designs have mer-
its for collecting substantive information on the
organizations themselves, they fail on capturing
the actual patterns of relationships, interdepen-
dencies, and interactions with the environment
(Foray and Steinmueller, 2003; Grindley et al.,
1994). The heterogeneity of relations within the
network thus remains opaque.

Atomistic Relations. A second research design
typically draws random samples of particular
relationships to analyze associations with either
antecedent or outcome variables. Such designs
have been appropriate, for instance, to examine
the extent of cooperation within an industry,
assess the effect of client referrals on the loca-
tional structure and geographical expansion of
professional service firms (Glückler, 2006), or
examine ‘the nature and geography of knowl-
edge linkages’ (Calignano et al., 2018: 1493).
Although the focus on dyadic ties can be valu-
able in many research contexts, such treatment
of relations does not take into account the topo-
logical structure in the overall network of rela-
tions. Instead, the surveyed relations are random
samples of isolated relationships – a case of
dyadic atomism (Granovetter, 1992) – which
do not permit any knowledge about the connec-
tivity of the network as a whole.

In both research designs, the empirical obser-
vation of networks remains either on the level of
the network as a monadic unit or on the level of
isolated dyadic relations. Coleman criticized
this approach as ‘fragmented psychology’
(Coleman, 1958): how, for example, could the
spread of information be investigated if the
ways of spreading, that is, the communication
relations between the actors, were not taken into
account? It is a fundamental critique of the prac-
tice of traditional research designs to investigate
relational phenomena with random samples and
to exclude connectivity as the actual core of the
phenomenon. Instead, an analysis of interaction,
communication, role expectations, and control
is inevitable to understand the economic oppor-
tunities and consequences of individuals and
firms (Abbott, 1998; Freeman, 2004).

A social network consists of a specific num-
ber of relationships with the additional charac-
teristic that the structure of these relationships
as a whole can be used to interpret the actions of
the individual (Mitchell, 1969). The conse-
quences of this assumption are fundamental: the
locations, positions, and roles of actors in a net-
work influence the actor’s opportunities and
constraints. Such thinking has converged across
the board of the social sciences to what is called
relational thinking (Bathelt and Glückler, 2003;
Emirbayer, 1997; Ettlinger, 2001; Fourcade,
2007; A Jones, 2014; Yeung, 2005). The com-
mon understanding of these approaches is
expressed rather radically in the ‘anti-
categorical imperative’ (Emirbayer and Good-
win, 1994). It is the normative assumption that
social phenomena as identity, power, status,
competitive advantage, entrepreneurial spirit,
social capital, or knowledge are not inherent
ontological attributes of actors, but expressions
and consequences of the history of interactions
and relations in a network. The relational per-
spective is suitable to understand individual and
collective opportunities for action as a condition
and consequence of the specific structure of social relations. Such a theoretical view requires an analytical turn toward analyzing connectivity in social relations. Methods of network analysis offer numerous measures to analyze the aspects of connectivity at three different scales: the level of nodes (individuals, organizations), subgroups (e.g., departments, families, clusters), and of the network as a whole (e.g., positions, roles, centralization). Recent research has started to examine the interdependencies across multiple levels, such as the effects of inter-organizational relations on the formation of interpersonal ties, and vice versa (Lazega and Snijders, 2016).

Proposition 1: Studying networks requires a relational perspective that focuses on the relationships between actors and the connectivity of the overall network in addition to the substantive properties of actors. Networks and individuals can no longer be examined as part of random samples but should be examined in their specific connectivity.

2 Beyond Formalism: The Contingent Relation Between Structure and Meaning

Recent discussions both within and between the social and natural sciences point to the limits of formalism and the implicit hope for universal structural explanations of the social world (Borgatti et al., 2009; Erikson, 2013; Hidalgo, 2016). The fact that natural scientists have discovered social networks as a research object has led to the confrontation of quite distinct research motivations. While natural scientists seek to demonstrate universal and nonrandom properties across different networks, social researchers seek to find the structural particularity in each empirical network to analyze their differential effect on varying social outcomes (Borgatti et al., 2009). In natural science, molecules with the same composition and structure of atoms generally have the same properties, whereas the same structure of social relations may lead to different types of behaviors and also different endogenous dynamics of network formation. In its extremes, research interests range between the search for universal network rules, on the one hand, and for comprehensive network narratives, on the other. Erikson (2013) addresses these poles as relationalism versus formalism. By doing so, she argues that not all empirical network research has also been ‘relational’ because relationalism refers to an epistemological position rather than only the operational quantification of links in a network.

In contrast to the so-called substantionalists (Emirbayer, 1997) and formalists (Erikson, 2013), a relational perspective comprises an understanding of context and meaning to account for the contingency of network structure. It acknowledges that social actors are inseparable from the transactional contexts within which they are embedded (Emirbayer, 1997; Granovetter, 1985). Whereas universal phenomena can be studied with statistics, contextual phenomena require network analysis, and evolutionary phenomena require historical analysis (Abbott, 1998).

Newman et al. (2001) show that in some cases, random networks offer accurate predictions of empirically observed networks, whereas in other cases, for example, interlocking directorships, they fail to account for the observed patterns of connectivity. By observing such discrepancies, they suggest to use random models only as baselines (Barabasi, 2016) to identify specific empirical features. A comparison between observed and modeled networks helps assess the magnitude of a fit or misfit, yet it does not offer any explanation of the social processes leading to an observed network-specific structure. In other words, it remains a contextless analysis.

In contrast to relational determinism, the formal structure of a social network is contingent on the meaning of the social relations and,
conversely, has contingent social effects on the actors involved in a network (Borgatti et al., 2009). Cultural frames and embedded meanings are crucial for understanding how certain relationships are formed and what kinds of structures emerge from them (Murphy, 2018). Even identical locations in a formal network may yield different actions and opportunities. Thus, the brokerage advantage of a central location in the network can be interpreted both for tertius gaudens strategies (Burt, 1992), that is, for the opportunistic privatization of broker advantages, and for tertius iungens strategies (Obstfeld, 2005), that is, for establishing new links between so far disconnected positions to enable collective advantage. Hence, it is not possible to determine a universal social outcome to a specific structural position a priori.

A second example shows that the same location of an organization in an industry network can be associated with very different outcomes: Close and dense relationships in a mature and stagnating market environment were found disadvantageous, whereas they proved advantageous in the context of emergent markets (Rowley et al., 2000). Likewise, the same structural features of a network, such as tie strength or structural holes, can both help or hinder the creative process toward innovation, depending on the stage of the idea journey (Perry-Smith and Mannucci, 2017). What is more, the effect of a network structure on innovation is contingent upon the cultural frame that actors choose to activate parts of the network features (Perry-Smith and Mannucci, 2017).

A third example refers to the difficulty of locating power in formal positions of network analysis: Power is only effective in relational exchange with other actors and is therefore constitutionally anchored in the network (Emerson, 1962). Yet despite all their efforts, power dependence researchers have not succeeded in solving the localization problem (Willer, 1989), that is, in assigning actual power relations to the positions of a network. Thus, powerful actors are not found exclusively in central positions, where they can actually be expected, but also in peripheral regions with little networking. Ultimately, the limits of social network analysis lie in the fact that it cannot explain the underlying macro-cultural discourses (Lawrence and Phillips, 2004), institutional contexts (Martin, 2000), and cognitive frames (Perry-Smith and Mannucci, 2017) that together affect how the structure of a network is associated with social outcomes. Obvious examples of extra-network forces that affect the formation of network relations are changes in regulation, for example, antitrust and tax legislation on industry-bank co-ownership (Höpner and Krempel, 2004), and changes in technology, for example, the rewiring of global trade relations in the course of the digitization of the photo industry (Panitz and Glückler, 2017). As Mizruchi (1994) puts it in a nutshell:

Network theory can explain why, given that a person’s friends are political liberals, the person is likely to hold liberal positions as well. [...] But the network approach cannot explain why particular groups of people hold liberal views in the first place. (Mizruchi 1994: 336)

The challenge for relational theory, hence, is how to capture the interdependence of the connectivity and the meaning of social relations simultaneously (Oberg et al., 2017; Pachucki and Breiger, 2010). The core concern of this critique is to integrate social network analysis, which examines formal patterns of social structure, with cultural approaches that are interested in the reconstruction of meaning in social relations (Mische, 2011). The concern of cultural approaches is to grasp the subjective and shared meanings in social action, social institutions, as well as in social forms, such as groups, teams, organizations, or movements. In human geography, we recognize at least three such approaches, including actor–network theory (e.g. Grabher, 2006), practice theory (e.g. Murphy, 2018; A Jones, 2014), and cultural geographies of the
economy (e.g. Berndt and Boeckler, 2009; Mützel, 2009). When it comes to empirical research, these approaches often rely on qualitative data and use interpretative methods to understand the social meaning in which the interactions of people are embedded. And although there have been recent claims to analyze the interdependence between formal networks and institutions to explore the co-evolution of meaning and structure (Lazega, 2018; Powell and Oberg, 2017), it remains an open question whether and how existing network studies have combined context-sensitive cultural approaches with formal approaches to learn about meaningful networks.

Proposition 2: Networks are not only formal links between social actors, but they generate meaning and, inversely, are structured by meanings that inform social behavior. Because connectivity and social meaning co-evolve, network research needs to be sensitive to the contextuality of networks and their contingent effects on social outcomes.

3 Beyond Neutralism: On the Performativity of Network Research

The Heisenberg uncertainty principle suggests that observing a system may actually transform the system (Borgatti et al. 2009). If this is true for physics, it is even more obvious for a social world characterized by double hermeneutic (Giddens, 1984): When beliefs and theories about a social phenomenon become known, people use this knowledge to reflect and eventually change their behavior. The theories with which we believe to discern social reality may actually convert reality in a way to gradually conform to the theory (Berndt and Boeckler, 2009). Performativity research pursues the question of how (scientific) models do not describe or explain reality, but how they produce reality themselves (Callon, 1998). The case of the stock option pricing model that gradually transformed the pricing practice at the Chicago stock exchange is a fascinating empirical illustration of the performative effect of theory on economic life (MacKenzie and Millo 2003). The emergence of online social networks and the proliferation of network algorithms that recommend users who else to connect with are a popular illustration of the performativity of network methods (Healy, 2015). In professional contexts, organizational network software offers tools for managers to assess their network on their own and to draw lessons for their strategic network action: ‘welcome to your personal network action plan’ (Cross 2009). In academic network research, network methods become performative in two ways.

First, primary data collection implies the interaction between the researcher and the actors in the field. Interview and survey questions raise the awareness of respondents about their relations; make them remember and reassess colleagues, superiors, and customers; and they sensitize respondents to the meaning of distinct types of relations and the notion of networks in the many contexts of a workplace, a competitive market, an organizational field, a governance situation, and so on. The more interactive the research process is between researchers and respondents, the more influential can conversations and feedback become for future actions in the network. Network research thus already contributes network practices during the process and without its findings. Such high levels of intervention in the field require researchers to comply with strong ethical guidelines and to avoid any harmful consequences for the participants, for example, if management implements changes based on the research findings to the disadvantage of some participants (Borgatti and Molina, 2003).

Second, Social network analysis (SNA) is a ‘non-neutral analytic device’ (Scott, 2015) in that its concepts and findings may affect individual and collective strategies of rewiring existing networks. An empirically extremely
A robust finding from network research is, for example, the connection between broker positions in networks and positive employee evaluations, bonus payments, and above-average salary development of managers in their peer group (Burt, 2004). Without scientific research, this association would remain unknown and could not be used as a source of the strategic behavior of the actors in the network. Due to publications and training, these concepts increasingly penetrate the minds of managers who learn that opportunistic network strategies (e.g. structural holes) boost individual career opportunities. Interestingly, research shows that the individual benefits of brokerage disappear when everyone seeks a brokerage position and establishes or breaks off their relationships accordingly (Buskens and Rijt, 2008). The CEO of a large corporation that we surveyed in our own research recognized the problem of privatizing network benefits at the management level, and so they started to give new thought to how they could encourage their employees to a more collective commitment and to the creation of opportunities for third parties (Obstfeld, 2005).

Proposition 3: Network analysis inherently transforms the reality of social relations. It interferes with and thus affects the social world during primary data collection, and it creates theories and concepts that affect the way actors think about goals and strategies to evaluate and rewire their networks accordingly. Hence, network research needs to be sensitive to the empirical context, to reflect its observations in the light of actor knowledge, to respect research ethics in the field, and to recognize the potential performative effect of its findings.

In summary, according to our assessment of the challenges in the field, we posit three requirements for appropriate designs of relational analysis. Network research has to be, first, relational, that is, to capture the connectivity of social relations and social phenomena; second, contextual, that is, to grasp the meaning of interactions and relations as well as their contingency in a particular spatiotemporal context; and, third, reflexive, that is, to understand, sensitize, and responsibly mediate the performative interference of research with the social world. To what extent, however, does extant research practice meet these requirements? And what are potential techniques or elements to accomplish relational, contextual, and reflexive designs in practice? To explore the breadth of research practices in human geography, we present a comprehensive meta-analysis of published research in the next section.

III A Meta-Analysis of Network Studies in Human Geography

We used the Scopus database to screen a selection of 28 journals in the field of human geography for those publications that made use of network methods in their research. The analysis started with a total of 41,417 articles published between 1990 and 2018 (Table 1). Using the statistics program R, we systematically screened all articles for the presence of a defined set of key words in titles, abstracts, and author-provided key words. Altogether, 4917 papers (11.9 per cent) mentioned the term ‘network’ more generally, of which 194 articles referred to concepts of networks (‘network theory’) and another 578 mentioned techniques from the broader set of network methods (‘network analysis’). Because of our interest in the ways in which researchers in human geography have used network methods, we consider the 578 articles in the category ‘mentions of network analysis’ in Table 1 for further analysis. We used MaxQDA (VERBI Software, 2019), a software for qualitative content analysis, to integrate all full texts into one data corpus and to analyze the articles for the appearance of predefined key...
words covering most of the contemporary techniques and measures in network analysis.

Once the text corpus was established, the meta-analysis proceeded in three steps. First, we defined a code-tree including four elements of a research design: (i) *data*, that is, type of nodes, types of ties, and level of analysis; (ii) *data collection*, that is, primary qualitative (e.g. interviews), primary quantitative (e.g. survey) and secondary (e.g. a database), and the size of the network studied; (iii) *network measures and methods* (e.g. centrality, block-modeling); and (iv) *type of design*, that is, single versus mixed methods and single versus multiple observations of the same types of ties and nodes.

Second, we submitted these codes to an automatic coding process of all 578 full texts in MaxQDA and checked whether an article mentioned or discussed network analysis or really applied network methods to original empirical research. By reviewing the codings, we identified three groups of articles. Group 1 includes 105 articles that mentioned network analytical concepts without using them for own empirical research. Typically, these papers acknowledge network analysis as a methodological opportunity (Wójcik, 2013) or refer to some of its concepts such as connectivity (Roe, 2006; Salet, 2008). Group 2 includes 155 articles that conceptually discuss or elaborate on network analysis as a methodology without applying it to empirical analysis. Good examples are developments, critiques, or propositions of new network analytical methods, such as the comparison of certain measures (Broekel et al., 2014; Mamun et al., 2013). Other examples include theoretical reviews and discussions of network approaches (Glückler and Doreian, 2016; Grabher, 2006; Hodgetts, 2018; Schwannen, 2017; Smith, 2014). Group 3 includes those 318 articles for which we confirmed truly empirical applications of network analysis, including simulations based on empirical data, modeling, qualitative and quantitative explorations, and so on.

Third, the meta-analytical codings were the starting point for a more detailed manual analysis, in which we reviewed the codings in the empirical applications to confirm their validity. In many instances, when reading the context of the articles, we either removed, recoded, or further detailed the codings. After having validated the codings, we analyzed this body of literature and computed descriptive statistics on how researchers in human geography have used network methods in empirical research applications. Despite the small share of only 1.4 per cent in all research published in the 28 journals, network analysis has been used in the most diverse contexts, scales, and in relation to the most diverse objects. Its applications range from small-N qualitative network ethnographies to large-N big data networks comprising millions of nodes. For the purpose of an overview of the variety of uses, we

---

**Table 1. Meta-analysis: Number of articles by key word in the title, abstract, or author key word.**

| Key words                                      | Studies (frequency) | Share (per cent) |
|-----------------------------------------------|--------------------|------------------|
| Total                                         | 41,417             | 100.00           |
| Mentions of ‘network’                         | 4917               | 11.87            |
| Mentions of ‘network theory’                  | 194                | 0.46             |
| Mentions of ‘network analysis’                | 578                | 1.40             |
| Mentions but no application of network analysis| 105                | 0.25             |
| Conceptual discussion but no application of network analysis | 155                | 0.37             |
| Confirmed applications of network analysis    | 318                | 0.77             |
Types of Nodes, Types of Ties, and Levels of Analysis

Human geographers have studied a wide variety of network nodes, including airports, bus stops, cities, regions, countries, firms, industries, technologies, artists, inventors, authors, travelers, commuters, social media users, and so on. These different types of nodes can be classified into four categories (Table 2): individuals (11 per cent), organizations (38 per cent), territories (47 per cent), and other nonacting nodal categories (4 per cent). This distribution illustrates the tendency of studies on geography to apply network analysis to nonsocial nodes to examine linkages between aggregate territorial units or other artifacts. While the common practice of aggregating individuals and organizations into places and places into regions reduces complexity and serves the ‘spatialization’ of social networks, at the same time, this operation converts social relations between social actors into hyperrelations between nonsocial nodes.

Similarly, human geographers have looked at a vast variety of different types of ties or relations between the research subjects. Building on Borgatti et al. (2009), we distinguish between four fundamental types of ties4: similarities, relations, interactions, and flows (Table 3). This distinction is crucial because each type of tie implies a different logic as to what a connection actually means and what its potential effects on the network structure may be. Being similar according to a certain characteristic, for example, does not imply mutual contact, acquaintance, or even awareness between people. Hence, similarities can hardly be interpreted as any meaningful expression of social relations or interactions. In contrast, a social relation of kinship, mentorship, or collegiality does imply not only mutual awareness but often reflects deeper relations of, for instance, affection, solidarity, or trust. The type of tie also makes a difference for what actually happens on those links. In the case of interactions, which represent a third type of ties, actors exchange meaningful symbols, affection, or information or they engage in collaboration, conflict, play, learning, co-creation, or other activities. In contrast to this interaction, the final type of tie refers to flows, that is, transactions of content, resources, or commodities. While all these types of ties look identical when mapped on a network graph, they require differential theorization and imply differential inferences on the conditionality of and impact on network structure.

It is a shortcoming in some contemporary network research to disregard the logical differences between distinct types of ties and to make unjustified assumptions and inferences.

Table 2. Types of nodes analyzed in network studies within human geography.

| Type of nodes | Share (per cent)* | Use in human geography |
|---------------|-------------------|------------------------|
| Individuals   | 11                | Citizens, inventors, entrepreneurs, employees, travelers, board members, scholars, migrants |
| Organizations | 38\(^a\)           | Public, private and nonprofit firms, research organizations, start-ups, gangs |
| Territories   | 47                | Airports, bus stops, cities, regions, countries, NUTS-2 and 3 regions, metropolitan areas, ports, world regions |
| Other         | 4                 | Industries, technologies, documents, themes and topics, panel sessions, publications |

\(^a\)A small share of 1 per cent of the articles studied networks that included nodes of both individuals and organizations.
Table 3. Types of ties analyzed in network studies within human geography.

| Type of tie         | Share (per cent) | Subtype                  | Use in human geography                                                                 |
|---------------------|------------------|--------------------------|----------------------------------------------------------------------------------------|
| Similarities        | 30               | Location                 | Spatial proximity, co-presence in a region or city                                       |
|                     |                  | Membership               | Affiliation to the same employer, consortium, cluster association, research program,     |
|                     |                  |                          | syndicate or project, co-web links, co-authorship, co-citation, co-patenting,            |
|                     |                  |                          | co-ownership board of director, advisory board, conference, panel session, other        |
|                     |                  |                          | events                                                                                 |
|                     |                  | Attribute                | Same income group, same industry, same qualification, same profession, same gender,    |
|                     |                  |                          | age-group, etc.                                                                         |
| Relations           |                  |                          |                                                                                        |
| Social relations    | 21               | Individuals              | Acquaintance, friendship, kinship, family, leisure, employment relation, colleague,     |
|                     |                  |                          | manager of, supervisor of knowledge relationships, likes on Instagram, emotional       |
|                     |                  |                          | support, professional endorsers and contacts                                           |
|                     |                  | Collective,              | Trade relations, buyer–supplier relations, contractual relations, sales agreements,     |
|                     |                  | organizational           | cooperation agreements, formal and informal firm cooperation, funding and              |
|                     |                  |                          | partnership relations, permanent and strategic relations, R&D alliances, innovation-    |
|                     |                  |                          | related cooperation linkages, important network partners, relations of rivalry and      |
|                     |                  |                          | competition, war declarations                                                        |
| Nonsocial relations | 19               | Physical and             | active rail tracks, travel connections by airline, flight, ferry, bus, train, habitat   |
|                     |                  | infrastructure           | connectivity, hyperlink connections, in- and out web links, computer and IP-link       |
|                     |                  |                          | connections, accessibility of infrastructural networks, pedestrian networks, road       |
|                     |                  |                          | and railway networks, transportation, transit routes                                   |
| Interactions        | 7                |                          | Telecommunication, social network service, letter, fax, electronic mode, email, face-   |
|                     |                  |                          | to-face communication, frequency in interaction in innovation processes, CEO and        |
|                     |                  |                          | researcher communication, Meetings during trade fairs, talk, collaboration               |
| Flows               | 23               |                          | Passenger, commuter, cargo and container flows, frequency on airline routes, freight    |
|                     |                  |                          | traffic, disease transmission flows, financial flows, VC investments, work flows, data,|
|                     |                  |                          | information and knowledge flows, geo-tagged travel, shopping trips, migration,        |
|                     |                  |                          | mobility of employees, retweeting, trade flows, flight                                  |

IP, Internet protocol; R&D, Research and development; VC; Venture Capital.
Examples from innovation studies and global city research, so far two major fields of application of network analysis, illustrate the problem of sometimes unsubstantiated meaning ascription. First, in innovation studies, scholars sometimes observe co-membership of people in the same project, yet they interpret this similarity as a case of interaction although it is not evident that any information was ever exchanged. Sometimes, research consortia can grow very large, where only a small group of participants actually engages in interactions. A second example is found in studies on global city networks. Whereas the observations are either similarities, for example, the co-occurrence of corporate subsidiaries between cities, or flows of people, for example, passengers traveling between the cities, scholars often tend to overload the meaning of these types of ties by ascribing higher order social relations (power, dominance, hierarchy). Smith (2014) offers a succinct critique of this research practice by pointing to the conceptual incongruence between the measurement of similarities and their interpretation as ‘command and control’ structures. In addition, these studies face a multilevel problem by attributing these meanings to higher order types of nodes (from individuals or corporate branches to cities or to countries). The validity of such an upscaling of meaning to aggregate higher order levels would require empirical analysis and theoretical justification in their own right. These meaning ascriptions are cases of unjustified correspondence between the referent and the reference, to frame it in semiotic terms, where author-constructed relations of similarity are assumed to represent the meaning of real social interaction.

A similar problem of multiple meaning ascription to the same observation becomes apparent in innovation network studies. Co-occurrences of applicants or inventors in patent statistics, for instance, have been interpreted as social relations of co-ownership (Belderbos et al., 2014) and as flows of information between individual inventors (Breschi and Lissoni, 2009) as well as between collective organizations (Jaffe and Trajtenberg, 2002). All these interpretations are surfing on the same initial observations, yet their meanings are diverse, which ultimately affects the logic of theorizing the nature of the network. So far, the meta-analysis conveys that a substantial number of network studies in human geography have focused on nonsocial relations. Almost a third of all studies looked at similarities, such as spatial proximity or co-membership in specific categories, 19 per cent on nonsocial relations, for example, between websites or road infrastructure, and another 23 per cent looked at flows of information, finance, or commodities mostly between nonsocial actors such as cities or regions. Less than a third of all studies actually studied truly social relations (21 per cent) and social interactions (7 per cent).

One fundamental advantage of network analysis is that it allows for bridging the micro–macro divide between individual agency and social structure. This is facilitated by analyzing data on three different levels: the node level of individual or collective agency, the intermediate level of subgroups such as cohesive communities or clusters of equivalent relations, and the macro-level of the network as a whole. Our meta-analysis suggests that research in human geography is still constrained in describing the node level of networks or their relative amount or distribution within the studied network population (e.g. network density or centralization); 40 per cent of all studies make terminological reference to the analysis of the location of nodes in networks and most of these studies on the measure of centrality (Table 4); 32 per cent of studies refer to analytical descriptions on the network level that account for the amounts of ties in comparison to the number of nodes (e.g. density) rather than real structural properties. Recently, however, the literature has emphasized that the huge potential of using the structural information of the entire network to gain
more complex insights into the logic of connectivity between nodes, such as divisions of labor or core-periphery structures, has been largely left unexhausted (Glückler and Doreian, 2016). Fruitful techniques of network-level studies such as positional analysis (blockmodels) or the analysis of small-world structures (modularity) have been applied only recently in human geography (Etzabe and Valdálico, 2016; Glückler and Panitz, 2016; Henderson and Alderson, 2016; Prota, 2016; Tomasello et al., 2016).

Overall, network research in human geography has tended toward the analysis of nonsocial linkages between nonsocial nodes with a smaller share of work really looking at proper social networks of social interactions and social relations. Moreover, the majority of studies have concentrated on the node-level while missing out potential insights into the structure of subgroups and the network as a whole. The true potential of network analysis to support relational thinking in building theories of social networks still has to be unleashed.

### 2 Methods of Data Collection

The quality of coverage of a phenomenon as well as the validity of the meaning of the observations depends on data and the methods of data collection. According to our meta-analysis, secondary data collection has been prevalent in most network research in human geography. This form of empirical research offers the advantage of gathering information on large networks and reduces the problem of missing data (Ter Wal and Boschma, 2009). Four in five studies (84 per cent) drew on existing databases, for example, patent or publication databases, official documents, or interaction data from social media platforms. Network sizes vary between 3 and 1,000,000 nodes with a mean network size of 8039 nodes (Figure 1). Studies using secondary data to construct networks of smaller size often focused on aggregated relationships and connections between territories, such as world regions or countries. Large networks, on the other hand, are often constructed from similarities between individuals or organizations based on secondary data, such as co-publications (Van Meeteren et al., 2016), co-patenting (Graf and Henning, 2009), board memberships (Carroll, 2009) or comments, likes and re-tweets of entries in social network platforms (Boy and Uitermark, 2017). However, they come with some limitations. Large-N secondary networks (LNSNs) face problems of meaning and construct validity: to what extent do the stylized data represent the constructs of interest? For instance, do similarity relations of co-patenting validly represent the co-creation and sharing of knowledge between the involved actors? An extreme case of how LNSNs are likely to misrepresent the ‘true’
social networks are social media data (Ruths and Pfeffer, 2014): a population bias toward younger generations, opacity of data procession by the platforms, the inclusion of nonhuman actors, such as bots or spammers, and unknown criteria for limitations in access to these data altogether pose problems to interpret the network data as real social relations. This example also points to the problem of data procession: to what extent do multiple conversions, for example, symmetrization and dichotomization, distort the meaning of the original observations? Moreover, how does a quantitative secondary study control for the institutional and geographical context of a social network? Finally, another limitation to validity is the lack of reflexivity pointed out earlier. Collecting relational data without the conscience of the observed actors is exempt from conversation and engagement between the researchers and researched. Overall, while LNSN are good at capturing connectivity and gaining good coverage of a population, they are at risk of falling short on authenticity and internal validity. Hence, secondary relational data require careful validation with respect to construct validity.

In turn, primary network research enables one to identify and accurately understand social relations in close interaction with the field. The aim of primary data collection is to identify the qualities of relationships considered to be constitutive for a social network. It allows the observation of informal relationships such as giving advice (Lazega et al., 2012) or sharing expertise (Reagans and McEvily, 2003; Reagans et al., 2005) and thus detaches itself from the stylized facts of co-occurrences in patents, projects, and locations. This procedure automatically forces the researcher to immerse himself in the field. It opens up the possibility to raise the authenticity of the representation of a social network. However, the downside of primary data collection, no matter if conducted through interviews, participant observation, or surveys, is the level of nonresponse and incomplete coverage of the network population. Accordingly, our meta-analysis illustrates that small-$N$
primary networks (SNPNs) include smaller networks with an average network size of $N = 174$ in the case of network surveys with average response rates of 69 per cent. This is more than 45 times smaller than the average network size of secondary network studies. In the case of interview-based data collection, the average network size was difficult to correctly assess because often the size of the studied population was often left unmentioned. Critical questions arise: to what extent can primary data collection capture large empirical networks? To what extent can interviews and surveys achieve a full network census? To what extent can network ethnographies account for the effects of a network structure? SNPNs are conducive to creating authentic and meaningful representations of a context, yet run the risk of scoring low on connectivity and external validity.

Issues of internal and external validity become apparent in many studies that rely exclusively on a single-method research design. Latent problems associated with this research practice are an incorrect representation of constructs (thin data, construct validity), incomplete data coverage (missing data), inappropriate procedures, and unjustified interpretation of findings.

IV Combining Methods for Meaningful Relational Analysis

There are many and often conceptually overlapping criteria to assess the quality of empirical research. Essentially, an empirical piece of research should meet both the standards of internal and if intended, external validity (De Vaus, 2001). To be internally valid, the design needs to define valid constructs that measure what they mean to measure (construct validity), collect and represent meaningful (authenticity) and relatively complete observations (coverage), employ rigorous and proper procedures for analysis (rigor, reliability), and come to valid interpretations of the findings. To be externally valid, the analysis needs to be representative of a larger population (representativeness), which in the case of social networks is a fundamental problem due to the violation of statistical independence between the observations (Abbott, 1998; Sayer, 1992; Wasserman and Faust, 1994). Following the arguments of relational geography, a belief in the contextual nature of social networks contradicts the possibility of generic generalizations (Bathelt and Glückler, 2018; Ettinger, 2001; Mische, 2011; Mische and White, 1998; Pachucki and Breiger, 2010). Instead of generalizing universal regularities, a relational theory aims to decontextualize abstract principles from its context of study and to potentially transfer them to other cases by means of translating these principles into their contexts. Such a technique corresponds with the critical realist distinction between necessary and contingent conditions, where most social mechanisms and processes are held to depend on contingent relations (Archer et al., 1998; Sayer, 2000).

To systematically trade-off the limitations of ‘meaning’ in large-$N$ studies with the limitations of ‘structure’ and of data coverage in small-$N$ studies, it seems more appropriate to combine different techniques in mixed-methods designs. Mixed-methods approaches offer the opportunity to trade-off the advantages of connectivity, contextuality, and reflexivity as discussed in the sections above. The combination of quantitative and qualitative methods, in particular, has the potential to complement knowledge about relational form, that is, connectivity, and relational content, that is, meaning and context (Crossley, 2010). Following from our previous comparison of the strengths and weaknesses of large-$N$ quantitative and small-$N$ qualitative network studies, qualitative methods are appropriate for reconstructing and understanding the meanings that actors ascribe to their actions and social relations. Interpretative methods are particularly suitable for network research to reveal the contextuality of goals, interests, attitudes, action orientations,
practices and significant effects in addition to quantitative methods of social network analysis and to use them to interpret the formal structure. Many of the concepts used today in formal network analysis actually originated from qualitative research, for example, the concepts of density, cliques, or clusters (Domínguez and Hollstein, 2014).

Qualitative research is also useful in the absence of historical data to reconstruct and theorize the dynamics of social processes. Assuming that history and experience matters, the lack of knowledge about that history will not allow us to assess its impact on the presence. This is true for any method, and of course also for social network analysis. The only alternative to historical data is to build theory about mechanisms that constitute the processes, which are consistent with an observed outcome. In this case, we can identify these mechanisms in a current structure and draw inferences on past processes. Theoretical approaches such as path-dependency (Martin and Sunley, 2006) or imprinting (Marquis and Ticsik, 2013) are promising frameworks to inform the rising field of dynamic and evolutionary network analysis. Within our meta-analysis, only 24 per cent of all articles (77) included a time dimension of the studied networks. Of them, over 90 per cent draw on secondary data. This reflects the empirical limitations for theory building based on historical data as such information is quite rare and often traces only the quantitative aspects of relationships. An obvious example is organizational membership. Although we might know when a person has become a member, we do not know about the person’s actual activities. Often people are officially a part of an organization without any active role. Such activity levels change over time and thus change the quality of the relationships. It is here where mixed methods using qualitative and quantitative methods are especially valuable to capture the quality and the history of relationships.

Despite its potential, the use of mixed-methods has been an exception rather than a rule in network research within human geography over the last decades. Combining qualitative and quantitative network analysis in mixed-method designs is still an emerging field (Crossley, 2010; Crossley and Edwards, 2016; Domínguez and Hollstein, 2014; Edwards, 2010; Glückler et al., 2020; González Canché, 2019; Nooraie et al., 2018). Recent approaches range from network ethnographies (Berthod et al., 2017), cultural network approaches (Edelmann, 2018), and the use of participant observation in formal network analysis (Conti and Doreian, 2010) to the ‘quantitization’ of qualitative content (Williams and Shepherd, 2017). In the meta-analysis, only a small share of studies used multiple methods to analyze networks (Table 5). These mixed-methods studies collected data from diverse primary sources, including interviews, mental maps, activity diaries, and questionnaires, and also from diverse secondary sources such as private and official databases, online social networks, documents, e-mails, or websites. Predominant rationales for the mixing methods were to explore a phenomenon from different angles, to validate observations, or to interpret an empirical finding in the light of a theory (Table 6).

However, many multiple-method studies actually fail to combine the strengths of mixing methods as they use them in isolation from each other. For example, a comparative analysis of two regional cases each with different methods is not a mixed approach that contributes to cross-validation because it applies different methods to different observations in different contexts. At one end, we observed cases in which the main source of data collection were secondary databases, and only one interview was used to qualify the approach as mixed methods. Fortunately, at the opposite end, we also found articles that used mixed methods to conduct multiple triangulations: ‘Mitigation strategies included triangulation of data through physical observation, pilot
interviews to test and refine the questionnaire, use of skilled translators, audio recording of interviews (with consent) and use of independent translators to transcribe interviews’ (Chaudhury et al., 2017).

There are three general designs of mixing methods in social network research (Edwards, 2010): First, in a sequential design, either qualitative research or quantitative SNA is used as a starting point to then validate findings with subsequent use of complementary research techniques. Second, in a bifocal approach (Coviello, 2005), scholars rely on qualitative methods during data collection to capture the differential meanings of social relations, whereas they mix quantitative and qualitative methods only at the stage of data analysis. Third, qualitative and quantitative methods are used at both the stage of data collection and the stage of analysis to attain the full benefits from triangulation, a strategy adopted, for instance, in the ‘Situative Organizational Network Analysis’ approach (Glückler et al., 2020). Whereas this typology refers to different types of
sequencing and mixing of qualitative and quantitative methods, we would like to highlight three strategies for trading-off the tension between structure and meaning and for ensuring internal validity and potential transferability of research findings on meaningful social structure. All these strategies involve the use of various methods either in parallel or sequential ways of mixing.

(i) *Informed prespecification*: In line with relational thinking in human geography, this strategy aims at actively integrating the already existing substantive understanding of a particular research context into the specification of a formal network model (Brusco et al., 2011; Doreian et al., 2005). Both the contextual conditions and the researcher’s knowledge about this context are crucial to capture the specific social meaning of a particular network. Sometimes scholars have spent many years researching a community, region, or industry and have adopted a deep and intimate understanding of manifest and latent processes. Such prior contextual knowledge then permits the researcher to theoretically justify more formal analysis of network structure and even allow for the formulation of empirically grounded hypotheses and meaningful models (Glückler and Panitz, 2016; Prota, 2016).

(ii) *Triangulation*: Triangulation denotes ‘the combination of methodologies in the study of the same phenomenon’ (Denzin, 1978: 291) in a way that potentially compensates for the blind angles of individual methods and thus strengthens the rigor of the research process. The advantage of triangulation is that the overlapping of different methods compensates for the limits of single techniques and controls for method-dependent variations in the observation of a phenomenon. Ideally, then, triangulation facilitates the confirmation of the same finding through different observational or analytical techniques. Contradictory results obtained through different methods, on the other hand, offer the opportunity of searching for more context-specific explanations or pose new and original research questions (Jick, 1979). Triangulation can take many forms and involve parallel as well as sequential mixes of methods. A sequential approach may be helpful to first explore the variety and meanings of interactions and relations in a particular context and then select and devise appropriate items and categories for the systematic collection of relational data in a second step. The classic study on the paradox of embeddedness (Uzzi, 1997) is one example of this strategy, where ethnographic interviews served to grasp the meanings of interfirm collaborations, whereas a standardized secondary data set served to assess the impact of the structure of these collaborations on firm survival.

(iii) *Communicative validation*: A third strategy to enforce the internal validity of social network research is communicative or member validation (Guba and Lincoln, 1989; Seale, 1999). This strategy has two advantages. First, it exposes the researcher’s interpretations and conclusions to the views of the observed network actors. By engaging in conversation, both researchers and the researched individuals get the opportunity to question, challenge, and eventually reinterpret the meanings of the findings. Second, by reporting to and engaging with the network actors, the researchers can live-up to their ethical responsibility (Tubaro, 2019). Communicative validation should be a reflexive process avoiding unequal, exploitative, or non-serious conversation. The reflexivity of this process ‘refers to the constant backward and forward confirmation between the researcher and the participants under study in regard to re/constructions of constructions of the participants’ (Cho and Trent, 2006: 332). Only by engaging with the researched can network researchers become aware of and responsibly intervene in the intended and unintended performatve effects of any research findings on the future relational behavior of people in their particular context.
Through different methods, on the other hand, itates the confirmation of the same finding phenomenon. Ideally, then, triangulation facil-
tage of triangulation is that the overlapping of angles of individual methods and thus strength-
ways of mixing. Different methods compensates for the limits of
internal validity and potential transferability of research findings on meaningful social struc-
ture. All these strategies involve the use of var-
tory observation of the same set of nodes). Multiple observations are understood as observations made with independent methods. The table excludes cross-sectional comparative network analysis (multiple networks of various sets of nodes) and dynamic analysis (sequential observation of the same set of nodes).

When examining the body of literature covered in the meta-analysis for use of these validation strategies, we found only two articles referring to ‘pre-specification’ to support the validity of their constructs and models, 16 that referred to ‘validation’ and 15 that referred to ‘triangulation.’ A closer review of these articles suggested that several of these papers only referred to these strategies in a discussion rather than actually implementing them empirically. The number of studies reduced even further by employing a strict understanding of triangulation as a form of cross-validating constructs and phenomena through the use of independent methods for multiple observations of the same issue. However, taking into account that pre-specification, triangulation, and communicative validation may also be employed without explicitly referring to these terms, we acknowledge that it is difficult to screen the entire literature for a conclusive assessment. Instead, in Table 7 we got back to all articles in our sample that reported the use of multiple methods and checked for multiple or repeat observations as a means of cross-validation. Whereas the vast majority of 278 articles (87 per cent) had used single-method designs without between-method triangulation, the remaining 13 per cent of articles focused on repeated observations of the same nodes (5 per cent) or the same type of tie (5 per cent) or both (3 per cent). Although examples of this ambitious triangulation practice are still rare, it is here, where we expect valuable potential for future empirical network research. Apart from a good understanding of the research context, careful selection of the measures and rigorous procedures, between-method validation techniques promise to help reconcile the conceptual tension between structure and meaning in future relational analysis.

**Table 7. Types of triangulation designs of node and tie observations.**

|                | Single observation                                      | Multiple observations                                      |
|----------------|--------------------------------------------------------|----------------------------------------------------------|
| **Node**       |                                                        |                                                          |
| **Tie**        |                                                        |                                                          |
| Single observation | $N = 278$ (87 per cent)                           | Single observation of one type of tie for one set of nodes |
| Multiple observations | $N = 15$ (5 per cent)                               | Single observation of one type of tie and multiple observations of same nodes |
| **Multiple observations** |                                                        |                                                          |
| Single observation of a type of tie for one set of nodes using mixed methods | Multiple observations of a type of tie for one set of nodes using mixed methods |
| $N = 15$ (5 per cent) |                                                        | $N = 10$ (3 per cent)                                      |

*Note: This table looks at single/multiple observations of a set of nodes and a type of tie between these nodes within one network. Multiple observations are understood as observations made with independent methods. The table excludes cross-sectional comparative network analysis (multiple networks of various sets of nodes) and dynamic analysis (sequential observation of the same set of nodes).*

Conclusion

We have assessed three challenges for relational analysis in our field. First, we have found network research to be rather method-driven and often limited to descriptions of network characteristics. Borrowing from Werlen’s (1993) critique of the quantitative revolution in the human geography of the 1970s, one could say that social network analysis has so far been an only half-way revolution, in which the development of theory has clearly lagged behind the innovation of technical methods. However, for network analysis to enhance relational thinking, it should be used to design alternative explanations of social phenomena and to develop middle-range network theories.
Second, relational analysis is situated in a tense relation between formalism and relationalism on the one hand (Erikson, 2013) and between the universality and contextuality of structural principles on the other (Hidalgo, 2016). While network science is interested in the universal principles of network characteristics and, hence, deliberately compares apples with oranges, social network researchers are confronted with the problem of context-specific connections of meaning and therefore contingent social effects of otherwise identical network characteristics. Relational analysis only realizes the full value for relational theory if it succeeds to capture the topological characteristics of networks as well as their contexts of meaning (Pachucki and Breiger, 2010). This requires both a constructive exchange with relational approaches outside formal network analysis and in-depth field access, which is not limited to the processing of secondary data but seeks a qualitative understanding of the subject through mixed-method approaches.

Third, relational studies in geography have mostly contributed to node-related theorizing: how do people gain prestige, how do they get into central positions? What are the advantages (disadvantages) associated with central (peripheral) positions and which positions lead to what yield of social capital? In innovation research, in particular, node-based network theories such as structural holes or structural folds have been established. In contrast, network-related questions are still in their infancy. They relate to the underlying structural logic of the whole network and examine the constitutive significance of the overall structure, its evolutionary dynamics, and its collective antecedents and effects. Although methods such as blockmodel analysis or the analysis of dominant paths have been developed since the 1970s, theory-informed research on the internal structural logic of the division of labor in organizations, markets, and industries; on center-periphery structures in local and global production systems; or on the analysis of technological development paths is still rare.

Finally, and regarding the very research practice, the non-neutral position of network researchers combined with the performative effect of their research on the field requires reflexivity and ethical responsibility. Responsible social network research should comply with legitimate ethical guidelines (Borgatti and Molina, 2005) and include responsible strategies for sharing and disseminating research findings into any research design (Tubaro, 2019). Here, it is crucial to account for the meta-politics in network studies and big data analysis, including big data networks, and their tendency to overemphasize the constructive, functional, and beneficial opportunities while neglecting their constraints and negative impacts (Kitchin, 2013; Scott, 2015).

It is also important to recognize the a priori limits of network research. If social networks describe the structure of meaningful social relationships, then network research, like any other perspective, must also encounter limits in its descriptive and explanatory power. For example, people do not learn exclusively through interaction and social relationships, but also through noninteractive processes, that is, through distant observation and imitation, trial and error, or the consumption of media content (Glückler, 2013; Malmberg and Maskell, 2002). Accordingly, we cannot explain information, innovation, and learning processes solely by analyzing relationship structures. On the one hand, this insight implies that social network research cannot claim a universal explanation. On the other hand, it evidences that a relational perspective cannot be reduced exclusively to the formal analysis of social relationships but remains open to methodological pluralism because it should ultimately be a theoretical project.
Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Johannes Glückler https://orcid.org/0000-0002-2507-1556

Notes

1. The journals include Annals of the American Association of Geographers, Antipode, Area, Economic Geography, Entrepreneurship and Regional Development, Environment and Planning A, Environment and Planning C, Environment and Planning D, European Planning Studies, European Urban and Regional Studies, Geoforum, Geografiska Annaler B, Geographical Journal, Global Networks, Growth and Change, International Journal of Urban and Regional Research, Industrial and Corporate Change, Journal of Economic Geography, Journal of Rural Studies, Journal of Transport Geography, Papers in Regional Science, Progress in Human Geography, Regional Studies, The Annals of Regional Science, Tijdschrift voor Economische en Sociale Geografie, Transactions of the Institute of British Geographers, Urban Geography, Urban Studies.

2. Search key words included blockmodel, community detection, community structure detection, cut point, betweenness centrality, bonacich centrality, closeness centrality, degree centrality, eigenvector centrality, dominant path, ego-network, regular equivalence, structural equivalence, exponential random graph, ERGM, network analysis, network analy*, network centrality, network cohesion, network connectivity, network density, network size, small world.

3. Some articles treated individuals and organizations as nodes of the same order or analyzed them together in bimodal networks. If bimodal networks were only the starting point for the construction of uni-modal networks, only the resulting unimodal networks were considered for our analysis. In the case of eight articles, which treat organizations and individuals as nodes of equal order, we classified these nodes as organizations.

4. Assigning empirical measures of network relations to these four types of ties is not unambiguous and requires some decisions. Our classification refers stringently to the actual empirical observation rather than to the interpretation of that tie as suggested by the authors. (i) Similarity occurs whenever a relationship between two nodes is constructed by a common relationship to a third entity, a category, or person. In contrast, (ii) a relation implies that two nodes maintain some sort of direct, immediate linkage. A relation is social if it connects actors by meaningful social roles, for example, parent/children, supervisor/employee, partner, mentor/mentee, donor/donee, and so on. A relation is nonsocial if it connects nodes (not necessarily social actors) physically, for example, road, rail, utility, or internet connectivity between places or computers. Social relations often include elements of dynamic (iii) interaction, for example, to collaborate, co-create, or communicate, and (iv) flows, for example, transactions of information and goods but also of commodities, money, and so on. The association between social relations and social interactions is not trivial. For example, whereas the social relationship of kinship does not necessarily imply any interaction (theoretically, one can be a parent without knowing or interacting with one’s children), friendship relations become necessarily manifested through interaction. Similarly, a strategic partnership may ground on intense interaction and collaboration or precisely on the absence of any interaction, as in cases of collusion or informal agreements on anti-poaching. Accordingly, different types of ties often come with different meanings. Conversely, the observation of interactions does not necessarily lead to a more accurate measurement of social relations. The measurement of a single interaction between two persons, for instance, is not a sufficient cue to qualify their actual social relation. Furthermore, not all interactions and flows are necessarily ‘enacted’ or initiated directly by social actors. Especially studies that analyze networks on the internet recognize the importance of automated and artificially triggered interactions. Therefore, the actual empirical observation is more helpful for a classification of the type of tie than their interpretation.

References

Abbott A (1998) The causal devolution. Sociological Methods & Research 27: 148–181.
Archer MS, Bhaskar R, Collier A, et al. (1998) Critical Realism. Essential Readings. London, New York: Routledge.

Asheim BT (2002) Temporary organisations and spatial embeddedness of learning and knowledge creation. Geografiska Annaler. Series B, Human Geography 84: 111–124.

Barabasi A (2016) Random networks. In: Barabasi A (ed.) Network Science. Cambridge: Cambridge University Press.

Bathelt H and Glückler J (2003) Toward a relational economic geography. Journal of Economic Geography 3: 117–144.

Bathelt H and Glückler J (2018) Relational research design in economic geography. In: Clark G, Feldman M, Gertler MS, et al. (eds) The New Oxford Handbook of Economic Geography. Oxford: Oxford University Press, pp. 179–195.

Bathelt H and Li P (2020) Building better methods in economic geography. Zeitschrift für Wirtschaftsgeographie 64: 103–108.

Bathelt H, Golfetto F and Rinallo D (2014) Trade Shows in the Globalizing Knowledge Economy. Oxford: Oxford University Press.

Bathelt H, Malmberg A and Maskell P (2004) Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28: 31–56.

Belderbos R, Cassiman B, Faems D, et al. (2014) Co-ownership of intellectual property: exploring the value-appropriation and value-creation implications of co-patenting with different partners. Research Policy 43: 841–852.

Berndt C and Boeckler M (2009) Geographies of circulation and exchange: constructions of markets. Progress in Human Geography 33: 535–551.

Berthod O, Grothe-Hammer M and Sydow J (2017) Network ethnography: a mixed-method approach for the study of practices in interorganizational settings. Organizational Research Methods 20: 299–323.

Borgatti SP and Molina JL (2003) Ethical and strategic issues in organizational social network analysis. Journal of Applied Behavioral Science 39: 337–349.

Borgatti SP and Molina J-L (2005) Toward ethical guidelines for network research in organizations. Social Networks 27: 107–117.

Borgatti SP, Mehra A, Brass D, et al. (2009) Network analysis in the social sciences. Science 323: 892–895.

Boschma R (2005) Proximity and innovation: a critical assessment. Regional Studies 39: 61–74.

Boy JD and Uitermark J (2017) Reassembling the city through Instagram. Transactions of the Institute of British Geographers 42: 612–624.

Breschi S and Lissoni F (2009) Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows. Journal of Economic Geography 9: 439–468.

Broekel T, Balland P-A, Burger M, et al. (2014) Modeling knowledge networks in economic geography: a discussion of four methods. The Annals of Regional Science 53: 423–452.

Buscso M, Doreian P, Mrvar A, et al. (2011) Two algorithms for relaxed structural balance partitioning: linking theory, models, and data to understand social network phenomena. Sociological Methods & Research 40: 57–87.

Burt RS (1992) Structural Holes: The Social Structure of Competition. Cambridge, MA; London: Harvard University Press.

Burt RS (2004) Structural holes and good ideas. American Journal of Sociology 110: 349–399.

Buskens V and Avd Rijt (2008) Dynamics of networks if everyone strives for structural holes. American Journal of Sociology 114: 371–407.

Calignon D, Fitjar RD and Kogler DF (2018) The core in the periphery? The cluster organization as the central node in the Apulian aerospace district. Regional Studies 52: 1490–1501.

Callon M (1998) Introduction: the embeddedness of economic markets in economics. In: Callon M (ed.) The Laws of the Markets. Oxford: Blackwell, pp. 1–57.

Carroll WK (2009) Transnationalists and national networkers in the global corporate elite. Global Networks 9: 289–314.

Chaudhury AS, Thornton TF, Helfgott A, et al. (2017) Ties that bind: Local networks, communities and adaptive capacity in rural Ghana. Journal of Rural Studies 53: 214–228.

Cho J and Trent A (2006) Validity in qualitative research revisited. Qualitative Research 6: 319–340.

Coe N (2000) The view from out West: embeddedness, inter-personal relations and the development of an
indigenous film industry in Vancouver. *Geoforum* 31: 391–407.

Coleman JS (1958) Relational analysis: the study of social organizations with survey methods. *Human Organization* 17: 28–36.

Conti N and Doreian P (2010) Social network engineering and race in a police academy: a longitudinal analysis. *Social Networks* 32: 30–43.

Coviello N (2005) Integrating qualitative and quantitative techniques in network analysis. *Qualitative Market Research* 8: 39–60.

Crossley N (2010) The social world of the network: combining quantitative and qualitative elements in social network analysis. *Sociologica* 4: 1–34.

Cross R (2009) *Sample Personal Network Hardcopy Report*. Charlottesville, Virginia (USA). Available at: http://www.robcross.org/network_software.htm (accessed May 2012).

Crossley N (2020) *Connecting Sounds: The Social Life of Music*. Manchester: Manchester University Press.

Crossley N and Edwards G (2016) Cases, mechanisms and the real: the theory and methodology of mixed-method social network analysis. *Sociological Research Online* 21: 217–285.

Crossley N and Ozturk TA (2019) Music, social structure and connection: exploring and explaining core-periphery structure in a two-mode network of music festivals and artists in Turkey. *Miscellanea Anthropologica et Sociologica* 20: 192–210.

De Vaus D (2001) *Research Design in Social Research*. London: Sage.

Denzin NK (1978) *The Research Act*. New York, NY: McGraw-Hill.

Dominguez S and Hollstein B (2014) Mixed methods social networks research: design and applications. In: Granovetter M (ed.) *Structural Analysis in the Social Sciences*. New York, NY: Cambridge University Press.

Doreian P, Batagelj V and Ferligoj A (2005) *Generalized Blockmodeling*. Cambridge, UK: Cambridge University Press.

Edelmann A (2018) Culturally meaningful networks: on the transition from military to civilian life in the United Kingdom. *Theory and Society* 47: 327–380.

Edwards G (2010) *Mixed-Method Approaches to Social Network Analysis*. NCRM/015. Manchester: ESRC National Centre for Research Methods.

Emerson RM (1962) Power-dependence relations. *American Journal of Sociology* 27: 31–41.

Emirbayer M (1997) Manifesto for a relational sociology. *American Journal of Sociology* 103: 281–317.

Emirbayer M and Goodwin J (1994) Network analysis, culture, and the problem of agency. *American Journal of Sociology* 99: 1411–1454.

Erikson E (2013) Formalist and relationalist theory in social network analysis. *Sociological Theory* 31: 219–242.

Ettlinger N (2001) A relational perspective in economic geography: connecting competitiveness with diversity and difference. *Antipode* 33: 216–227.

Ettlinger N (2003) Cultural economic geography and a relational and Microspace approach to trusts, rationalities, networks, and change in collaborative workplaces. *Journal of Economic Geography* 3: 145–171.

Etzabe I and Valdaiso JM (2016) Measuring structural social capital in a cluster policy network: insights from the Basque Country. *European Planning Studies* 24: 884–903.

Foray D and Steinmueller WE (2003) On the economics of R&D and technological collaborations: insights and results from the project Colline. *Economics of Innovation and New Technology* 12: 77–91.

Fourcade M (2007) Theories of markets and theories of society. *American Behavioral Scientist* 50: 1015–1034.

Freeman LC (2004) *The Development of Social Network Analysis: A Study in the Sociology Science*. Vancouver, BC: Empirical Press.

Giddens A (1984) *The Constitution of Society. Outline of the Theory of Structuration*. Cambridge, MA: Polity Press.

Glückler J (2006) A relational assessment of international market entry in management consulting. *Journal of Economic Geography* 6: 369–393.

Glückler J (2007) Geography of reputation: the city as the locus of business opportunity. *Regional Studies* 41(7): 949–962.

Glückler J (2013) Knowledge, networks and space: connectivity and the problem of non-interactive learning. *Regional Studies* 47: 880–894.

Glückler J and Doreian P (2016) Editorial: social network analysis and economic geography – positional, evolutionary and multi-level approaches. *Journal of Economic Geography* 16: 1123–1134.

Glückler J and Panitz R (2016) Relational upgrading in global value networks. *Journal of Economic Geography* 16: 1161–1185.
Glückler J, Panitz R and Hammer I (2020) SONA: a relational methodology to identify structure in networks. Zeitschrift für Wirtschaftsgeographie 64: 121–133.

González Canché MS (2019) Geographical, statistical, and qualitative network analysis: a multifaceted method-bridging tool to reveal and model meaningful structures in education research. In: Paulsen MB and Perna LW (eds) Higher Education: Handbook of Theory and Research: Volume 34. Cham: Springer International Publishing, pp. 535–634.

Grabher G (2006) Trading routes, bypasses, and risky intersections: mapping the travels of ‘networks’ between economic sociology and economic geography. Progress in Human Geography 30: 163–189.

Graf H and Henning T (2009) Public research in regional networks of innovators: a comparative study of four East German regions. Regional Studies 43: 1349–1368.

Granovetter M (1985) Economic action and social structure: the problem of embeddedness. American Journal of Sociology 91: 481.

Granovetter M (1992) Problems of explanation in economic sociology. In: Nohria N and Eccles RG (eds) Networks and Organisations: Structure, Form, and Action. Cambridge, MA: Harvard Business School, pp. 25–56.

Grindley P, Mowery DC and Silverman B (1994) SEMATECH and collaborative research: lessons in the design of high-technology consortia. Journal of Policy Analysis and Management 13: 723–758.

Guba E and Lincoln Y (1989) Fourth Generation Evaluation. London: Sage.

Haggett P and Chorley RJ (1969) Network Analysis in Geography. London: Edward Arnold.

Healy K (2015) The performativity of networks. European Journal of Sociology 56: 175–205.

Henderson WD and Alderson AS (2016) The changing economic geography of large U.S. law firms. Journal of Economic Geography 16: 1235–1257.

Hess M (2004) “Spatial” relationships? Re-conceptualising embeddedness. Progress in Human Geography 28: 165–186.

Hidalgo CA (2016) Disconnected, fragmented, or united? A trans-disciplinary review of network science. Applied Network Science 1: 1–19.

Hodgetts T (2018) Connectivity as a multiple: in, with and as “nature”. Area 50: 83–90.

Höpner M and Krempel L (2004) The politics of the German company network. Competition and Change 8: 339–356.

Jaffe AB and Trajtenberg M (2002) Patents, Citations, and Innovations: A Window on the Knowledge Economy. Cambridge, MA: MIT Press.

Jick TD (1979) Mixing qualitative and quantitative methods: triangulation in action. Administrative Science Quarterly 24: 602–611.

Jones A (2014) Geographies of production I: relationality revisited and the ‘practice shift’ in economic geography. Progress in Human Geography 38: 605–615.

Jones M (2009) Phase space: geography, relational thinking, and beyond. Progress in Human Geography 33: 487–506.

Kitchin R (2013) Big data and human geography: opportunities, challenges and risks. Dialogues in Human Geography 3: 262–267.

Lawrence TB and Phillips N (2004) From Moby dick to free Willy: macro-cultural discourse and institutional entrepreneurship in emerging institutional fields. Organization 11: 689–711.

Lazega E (2018) Networks and institutionalization: a neo-structural approach. Connections 37: 7–22.

Lazega E and Snijders T (2016) Multilevel Network Analysis for the Social Sciences. Theory, Methods and Applications. Methodos Series. Heidelberg: Springer.

Lazega E, Mounier L, Snijders T, et al. (2012) Norms, status and the dynamics of advice networks. Social Networks 34: 323–332.

MacKenzie D and Millo Y (2003) Constructing a market, performing theory: the historical sociology of a financial derivatives exchange. American Journal of Sociology 109: 107–145.

Malmberg A and Maskell P (2002) The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering. Environment and Planning A 34: 429–449.

Malpas J (2012) Putting space in place: philosophical topography and relational geography. Environment and Planning D: Society and Space 30: 226–242.

Mamun SA, Lownes NE, Osleeb JP, et al. (2013) A method to define public transit opportunity space. Journal of Transport Geography 28: 144–154.

Mans U (2014) Revisiting city connectivity. Journal of Economic Geography 14: 155–177.
Marquis C and Tilcsik A (2013) Imprinting: toward a multilevel theory. Academy of Management Annals 7: 193–243.

Martin R (2000) Institutional approaches in economic geography. In: Sheppard E and Barnes T (eds) A Companion to Economic Geography. Oxford: Blackwell, pp. 77–94.

Martin R and Sunley P (2006) Path dependence and regional economic evolution. Journal of Economic Geography 6: 395–437.

Mitchell JC (1969) The concept and use of social networks. In: Mitchell JC (ed) Social Networks in Urban Situations. Analyses of Personal Relationships in Central African Towns. Manchester: Manchester University Press, pp. 1–50.

Mische A (2011) Relational sociology, culture, and agency. In: Scott J and Carrington P (eds) Sage Handbook of Social Network Analysis. London, New York: Sage, pp. 80–98.

Mische A and White H (1998) Between conversation and situation: public switching dynamics across network domains. Social Research 65: 695–724.

Mizruchi MS (1994) Social network analysis: recent achievements and current controversies. Acta Sociologica 37: 329–343.

Murphy JT (2018) The relational turn in economic geography. In: Cook G, Johns J, McDonald F, Beaverstock J and Pandit N (eds) The Routledge Companion to the Geography of International Business. London: Routledge, pp. 161–175.

Mützel S (2009) Networks as culturally constituted processes: a comparison of relational sociology and actor-network theory. Current Sociology 57: 871–887.

Newman MEJ, Strogatz SH and Watts DJ (2001) Random graphs with arbitrary degree distributions and their applications. Physical Review E 64: 1–17.

Nooraie RY, Sale JEM, Marin A, et al (2018) Social network analysis: an example of fusion between quantitative and qualitative methods. Journal of Mixed Methods Research 14: 110–124.

Oberg A, Korff VP and Powell WW (2017) Culture and connectivity intertwined: visualizing organizational fields as relational structures and meaning systems. In: Groenewegen P, Ferguson JE, Moser C, Mohr JW and Borgatti SP (eds) Structure, Content and Meaning of Organizational Networks (Research in the Sociology of Organizations, Vol. 53). Bingley: Emerald Publishing, pp. 17–47.

Obstfeld D (2005) Social networks, the tertius iungens orientation, and involvement in innovation. Administrative Science Quarterly 50: 100–130.

Owen-Smith J and Powell WW (2004) Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community. Organization Science 15: 5–21.

Pachucki MA and Breiger RL (2010) Cultural holes: beyond relationality in social networks and culture. Annual Review of Sociology 36: 205–224.

Panitz R and Glückler J (2017) Rewiring global networks in local events: congresses in the stock photo trade. Global Networks 17: 147–168.

Perry-Smith JE and Mannucci PV (2017) From creativity to innovation: the social network drivers of the four phases of the idea journey. Academy of Management Review 42: 53–79.

Powell WW and Oberg A (2017) Networks and institutions. In: Greenwood R, Oliver C, Lawrence T and Meyer R (eds) The Sage Handbook of Organizational Institutionalism. London: Sage, pp. 446–476.

Power D and Jansson J (2008) Cyclical clusters in global circuits: overlapping spaces in furniture trade fairs. Economic Geography 84: 423–448.

Prota L (2016) Toward a Polynesian network analysis: market and non-market forms of coordination in the rice economy of Vietnam. Journal of Economic Geography 16: 1135–1160.

Reagans R and McEvily B (2003) Network structure and knowledge transfer: the effects of cohesion and range. Administrative Science Quarterly 48: 240–267.

Reagans R, Argote L and Brooks D (2005) Individual experience and experience working together: predicting learning rates from knowing who knows what and knowing how to work together. Management Science 51: 869–881.

Roe EJ (2006) Material connectivity, the immaterial and the aesthetic of eating practices: an argument for how genetically modified foodstuff becomes inedible. Environment and Planning A 38: 465–481.

Rowe AD and Pitfield DE (2018) The challenge facing existing airport campaign groups when incorporating social media into their campaign: A social network analysis of Airport Watch’s social media utilisation. Geoforum 96: 236–247.

Rowley T, Behrens D and Krackhardt D (2000) Redundant governance structures: an analysis of relational
and structural embeddedness in the steel and semiconductor industries. *Strategic Management Journal* 21: 369–386.

Ruths D and Pfeffer J (2014) Social media for large studies of behavior. *Science* 346: 1063–1064.

Salet W (2008) Rethinking urban projects: experiences in Europe. *Urban Studies* 45: 2343–2363.

Sayer A (1992) *Method in Social Science*. London: Routledge.

Sayer A (2000) *Realism and Social Science*. London: Sage.

Schwanen T (2017) Geographies of transport II: reconciling the general and the particular. *Progress in Human Geography* 41: 355–364.

Scott M (2015) Re-theorizing social network analysis and environmental governance: insights from human geography. *Progress in Human Geography* 39: 449–463.

Seale C (1999) *The Quality of Qualitative Research*. London: Sage.

Smith CJ (1980) Social networks as metaphors, models and methods. *Progress in Geography* 4: 500–524.

Smith RG (2014) Beyond the global city concept and the myth of ‘command and control’. *International Journal of Urban and Regional Research* 38: 98–115.

Storper M and Venables AJ (2004) Buzz: face-to-face contact and the urban economy. In: Storper M (ed.) *Institutions, incentives and communication in economic geography: Hettner-Lecture 2003*. Stuttgart: Steiner, 102 S.

Storper M, Kemeny T, Makarem N, et al. (2015) *The Rise and Fall of Urban Economies: Lessons from San Francisco and Los Angeles*. Stanford, CA: Stanford University Press.

Sturgeon TJ (2003) What really goes on in Silicon Valley? Spatial clustering and dispersal in modular production networks. *Journal of Economic Geography* 3: 199–225.

Ter Wal ALJ and Boschma RA (2009) Applying social network analysis in economic geography: framing some key analytic issues. *The Annals of Regional Science* 43: 739–756.

Tomasello MV, Napoletano M, Garas A, et al. (2016) The rise and fall of R&D networks. *Industrial and Corporate Change* 26: 617–646.

Torre A and Rallet A (2005) Proximity and localization. *Regional Studies* 39: 47–59.

Tubaro P (2019) Whose results are these anyway? Reciprocity and the ethics of “giving back” after social network research. *Social Networks*.

Turkina E, Van Assche A and Kali R (2016) Structure and evolution of global cluster networks: evidence from the aerospace industry. *Journal of Economic Geography* 16: 1211–1234.

Uzzi B (1997) Social structure and competition in interfirm networks: the paradox of embeddedness. *Administrative Science Quarterly* 42: 35–67.

Van Meeteren M, Poorthuis A, Derudder B, et al. (2016) Pacifying Babel’s tower: a scientometric analysis of polycentricity in urban research. *Urban Studies* 53: 1278–1298.

VERBI Software (2019) *MAXQDA 2020, Computer Program*. Berlin: VERBI Software.

Wasserman S and Faust K (1994) *Social Network Analysis. Methods and Applications*. Cambridge: Cambridge University Press.

Werlen B (1993) *Society, Action and Space. An Alternative Human Geography*. London: Routledge.

Willer D (1989) Review: dependence and the problem of locating power. *Contemporary Sociology* 18: 142–144.

Williams TA and Shepherd DA (2017) Mixed method social network analysis: combining inductive concept development, content analysis, and secondary data for quantitative analysis. *Organizational Research Methods* 20: 268–298.

Wójcik D (2013) The dark side of NY–LON: financial xentres and the global financial crisis. *Urban Studies* 50: 2736–2752.

Yeung HW- (2005) Rethinking relational economic geography. *Transactions of the Institute of British Geographers* 30: 37–51.

**Author biographies**

**Johannes Glückler** is Professor of Economic and Social Geography and Fellow of the Marsilius Center for Advanced Studies at Heidelberg University. In his research he follows a relational perspective and builds on theories of organization, networks, and institutions in the study of the geography of knowledge and regional development. He is a founding board member of the German Society for Social Network Research DGNet and co-founder of the M.Sc. Governance of Risks and Resources at the Heidelberg Center for Latin America in Santiago de Chile.
Robert Panitz is an Economic Geographer working on knowledge and innovation geographies, digitization, and relocations in course of regulatory changes. Robert’s research follows a relational perspective. He is interested in social networks connecting individuals, organizations, and regions as well as processes that form new geographies of innovation.