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Solving Institutional Collective Action Problems in Multiplex Networks

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This essay extends theoretical arguments pertaining to single (uniplex) networks on how to solve coordination and cooperation problems associated with institutional collective action to multiplex networks constituting both formal and informal relationships formed by policy actors. While coordination problems reflect difficulties for actors in arriving at jointly desired policy outcomes, cooperation problems mean that actors have conflicting interests and, thus, face incentives to defect on each other. We propose multiplex versions of bridging and bonding networks, which have been found suitable for solving coordination and cooperation problems in single networks. Although our approach is limited to the simultaneous analysis of formal and informal relationships in policy networks, the arguments we present should aid researchers interested in analyzing policy networks beyond these manifestations of inherently complex relationships.

Keywords: Multiplex networks, institutional collective action problems, collaborative governance.

1. Introduction

Scholars have long recognized the multidimensionality of social systems in which large numbers of social agents are interconnected by a wide range of social relationships. These relationships include friendship, professional ties, exchanges of resources, such as information, goods and services, etc. While each type of relationship in these *multiplex networks* can be studied in isolation, a comprehensive analysis of a social system is incomplete without examining how the different types of relationships affect each other (Robins & Pattison, 2006; Bae & Feiock, 2012).

Studying multiplex networks are particularly important for solving institutional collective action dilemmas arising from the fragmentation of political and administrative authority in contemporary societies (Feiock, 2013). Fragmentation makes governance

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inherently complex, since a broad range of public, non-profit, and private organizations create a variety of formal and informal relationships in the management and delivery of public goods and services (Kettle, 2000; Feiock, 2009; Feiock & Scholz, 2010). Interdependencies among these organizations produce the need for coordinated behavior, which can be more easily accomplished in networks with certain features facilitating such behavior.

Formal relationships can be defined in statutes, which prescribe what a policy network should look like, or in contractual agreements that define the terms of relationships between two or more institutions (Edelenbos & Klijn, 2006; Klijn & Koppenjan, 2000; McGuire, 2002; Meier & O'Toole, 2003; Milward & Provan, 2006). But beyond the formal relationships, there are also informal links that may be formed between institutions for a variety of reasons, including similar ideological positions or policy views and agreements on organizational goals. Network structures emerge from these relationships that can shape the performance and stability of decision-making systems thus affecting the design and implementation of public policies (Feiock & Scholz, 2010). For example, in metropolitan service provision, local governments maintain contractual relationships with their peers for multiple services (Shrestha & Feiock, 2009; Shrestha, 2010; Andrew, 2009), but they may also be connected to each other through informal ties when they exchange information or meet one another in regional decision-making venues.

Considerable progress has been made in the policy sciences in understanding single types of relationships among actors in isolation, either formal (Andrew, 2009; Minkoff, 2012, 2013; Post, 2004; Shrestha, 2010;) or informal (Andrew & Carr, 2012; Feiock, 2009, 2013; Feiock, Lee, & Park, 2012; Lazer, 2011; Lee, Feiock, & Lee, 2012; Schneider, Scholz, Lubell, Mindruta, & Edwardsen, 2003; Scholz, Berardo, & Kile, 2008). Much less progress has been made in understanding the inherently multiplex character of these networks as they operate together. As a result, important questions remain unanswered. Perhaps the most basic one is: *How do actors shape their formal and informal relationships with each other when they face different types of institutional collective action (ICA) dilemmas?*

Our aim in this essay is to start a scholarly conversation that can lead to finding precise answers to this question. We believe this is an important endeavor because of the pervasiveness of ICA dilemmas and the ever-growing need to better understand the rather complex ways in which policy actors relate to each other when trying to solve those problems.

This essay proceeds first with a description of institutional collective action (ICA) problems. Then it discusses how those problems can be tackled by utilizing bridging and/or bonding capital in multiplex networks. Next, it introduces propositions for specific types of bonding and bridging configurations that one should expect to see when policy actors face coordination and cooperation problems. Finally, the essay highlights the limitations of and opportunities for analyzing multiplex networks.

2. ICA Dilemmas and Networks

Institutional Collective Action dilemmas arise from the fragmentation of authority in governance systems where policy decisions made by one jurisdiction to pursue its goals

are at odds with the activities or the collective benefits of the affected jurisdictions. These dilemmas are likely to manifest in the form of either coordination or cooperation problems. The former occurs when actors such as local governments have similar goals but disagree on how to reach them. For example, in metropolitan areas where multiple local governments coexist, shared interests in managing traffic flow to avoid congestion and gridlock lead cities to coordinate road construction, lane closures and the timing of traffic signals. Cooperation problems, on the other hand, take place when actors have conflicting goals and they are likely to defect on each other in order to reach those goals. For instance, cities trying to increase their tax base by attracting new businesses and investments may engage in offering competitive concessions that may lead to collective loss to the cities in the region.

Studies show that policy actors develop both formal and informal relationships to mitigate these types of problems (Feiock, 2013; Feiock & Scholz, 2010; Lubell, Schneider, Scholz, & Mete, 2002). For instance, local jurisdictions can become members of regional economic development partnerships in order to coordinate their economic development decisions (Feiock, Chen, & Hseih, 2016). Similarly, local governments can create networks of formal service contracts to minimize the risk of potential defection associated with the difficulty of monitoring contracts (Andrew, 2009; Shrestha, 2008; Shrestha & Feiock, 2013). In addition, representatives of the jurisdictions (either elected or appointed) can build mutual trust through informal exchange of information or meeting at shared venues in order to prevent potential non-compliance of the mutually agreed terms of contracts that are not easily verifiable.

Unfortunately, the specialized literature in public administration and policy has lagged behind in examining how these formal and informal relationships among policy actors help solve ICA problems. As a result, most analyses examining either formal or informal relationships have the obvious limitation of producing an oversimplified view of how collaborative processes really work.

3. Solving Coordination and Cooperation Problems in Multiplex Networks

Coordination and cooperation problems pose different challenges for policy actors in fragmented governance systems. In the presence of coordination problems, actors are interested in achieving a goal that they collectively deem valuable. This means that solving coordination problem requires that the actors exchange information in a way that allows them to converge on preferred courses of actions. Cooperation problems, on the other hand, are characterized by conflicting interests that can lead to widespread defection. In this type of scenario, actors require information that can help them detect and punish defection, which contributes to sustaining cooperation.

Previous research ties the solution to these types of problems to the existence of particular network configurations that can be formed in networks. Berardo & Scholz (2010), for instance, contend that actors facing coordination problems in networks seek to engage in structural relationships that give them quick access to relevant information on how

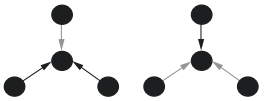
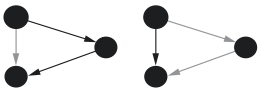
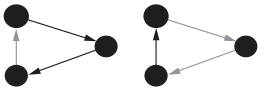
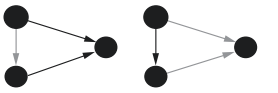
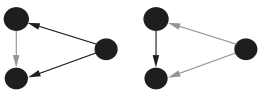
others are likely to act. Using data collected in self-organizing policy networks in 10 US estuaries, they show that bridging structures that are likely to facilitate quick convergence of policy views emerge when coordination problems are dominant.

On the other hand, when actors face cooperation problems, they are more prone to form bonding structures where redundant information flows among the members of the structure. This, in turn, helps promote and sustain cooperation because defection becomes costly as actors in the network can detect "cheaters" and inform others about their behavior (Coleman, 1988; Putnam, 2000).

Studying bridging and bonding structures is relatively straightforward in uniplex networks, where only one type of relationship is examined. In multiplex networks, however, it is somewhat difficult to determine how actors form bridging and bonding structures conducing for solving coordination and cooperation problems.

Table 1 contains structural configurations that we believe can be used to examine bridging and bonding in multiplex networks involving formal (black lines) and informal (red lines) relationships. Configuration 1A represents bridging through the establishment of multiplex in-stars. Configurations 1B to 1F represent bonding through the establishment of dyadic multiplex reciprocity (figure 1B) and four types of closed structures that indicate bonding where one of the links is informal and the other is formal (or vice versa).

Table 1
Structural Configurations for Solving Coordination and Cooperation Problems in Multiplex Networks

Type of ICA Problem (and configurations that solve them)	Description	Illustrative Structural Configurations
Coordination Problems (solved through Bridging configurations)	Multiplex in-stars (1A)	
	Multiplex reciprocity (1B)	
	Multiplex transitive closure (1C)	
Cooperation Problems (solved through Bonding configurations)	Multiplex cyclic closure (1D)	
	Multiplex closure for shared out-ties (1E)	
	Multiplex closure for shared in-ties (1F)	

Note: Black lines represent formal relations and red lines represent informal relations among actors.

We borrow these configurations from the research on Exponential Random Graph models applied to multiplex networks (e.g. Koehly & Pattison, 2005; Lomi & Pattison, 2006; Pattison & Wasserman, 1999; Wang, 2013; Wang, Robins & Pattison, 2009). This set of configurations should not be thought of as an exhaustive group of structures that indicates bonding or bridging; it is, rather, a straightforward way of showcasing the concepts in a simple multiplex setting (simple in the sense that there are only two types of relationships).[1]

Next, we discuss how actors form bridging and bonding configurations that are linked to solving coordination and cooperation problems in multiplex networks involving formal and informal relationships.

4. Solving Coordination Problems through Bridging in Multiplex Networks

We contend that actors facing coordination problems may benefit from creating multiplex in-stars. An in-star represents bridging because there is a central actor in the network that indirectly connects other actors (nodes) that would be completely disconnected in its absence.

The central (most popular) actor in the network functions as a depository of information and experience from both its formal and informal connections to others and is well positioned to control how those resources flow between other actors linked to it. For example, in metropolitan service delivery, counties and cities that are parties to multiple service contracts are able to gain economies of scale and economies of scope in production by entering into service contracts (or exchanging information informally) with a central city in the network that is heavily involved in exchanging information with other jurisdictions (or in entering service contracts with them). Attracting many service contracts means that the popular provider can consolidate the demand and coordinate the use of production and managerial inputs in service production leading to gains in economies of scale and economies of scope for all cities involved. In addition, informal exchange of information can lead to finding ways of enhancing economies of scale and scope benefits for all parties.

Because of the central position in the multiplex in-star configuration, the popular provider is also likely to be perceived as credible and competent, which is a critical piece of information for other nodes when they are looking for potential partners (Gulati & Gargiulo, 1999).

5. Solving Cooperation Problems through Bonding in Multiplex Networks

Actors facing cooperation problems can create bonding network structures that facilitate the flow of overlapping information among the participants. This, in theory, may enable them to detect and punish defective behavior thereby ensuring credibility of commitment necessary to achieve cooperation. This reasoning is directly applied to uniplex

[1] The prevalence of these structures in multiplex networks can be modeled with the XPNet software available at http://sna.unimelb.edu.au/PNet.

networks where the links between the actors contain information about each other's behavior, but the argument can be expanded to the study of multiplex networks composed of both formal and informal types of links. We first describe a simple version of bonding—multiplex reciprocity—followed by more complex versions that are defined by the existence of closure structures involving a larger number of actors.

6. Multiplex Reciprocity

Creating reciprocity across ties of different types, or *multiplex reciprocity*, is one way to mitigate problems of credibility of commitment and decrease the likelihood of defection. Multiplex reciprocity occurs when two actors create a reciprocal relationship formed by two types of ties, as shown in figure 1B. An example of multiplex reciprocity could be city A supplying police services to city B (a formal tie), while city B supplies city A with information on how to improve its fire department capabilities (an informal tie). In multiplex networks where exchanges involve multiple resources, there are more ways in which organizations can create multiplex reciprocity than in networks where organizations are linked by only one type of relation. Since these exchanges are maintained through mutually supportive relationships, organizations tend to balance their relations by entertaining exchange relations across different networks (Lomi & Pattison, 2006).

Multiplex reciprocity creates mutual commitment by both parties and thereby reduces the risk of defection. Reciprocity also helps partners to know each other better which develops into mutual trust and improves collaboration by reducing behavioral uncertainties (Uzzi, 1997). It can develop into expectations of taking turns, mutual obligation, and trust in exchange (Coleman, 1988). This notion is consistent with the social capital argument that actors involved in a variety of cross-cutting venues are more likely to create mutually trusting environment for improved cooperation (Putnam, 2000).

Reciprocity can also incentivize parties to fulfill their commitment as they can punish each other by declining to cooperate in the next round. The presence of "mutual deterrence" (Williamson, 1981), in reciprocal relations also forces both parties to build strong, credible ties. In the case of service contractual ties susceptible to opportunism, Shrestha and Feiock (2009) found that local jurisdictions in Florida adopted cross-service reciprocity because it provided assurance to both the recipient (buyer) and the supplier (seller) jurisdictions of the credibility of commitment in service transaction. This suggests that policy actors facing cooperation problems in institutional collective action situations are more likely to develop multiplex reciprocity to address the problems.

7. Multiplex Triadic Closure

While reciprocity is dyadic, closure in social networks is a group feature. The main idea underlying social closure is that actors have a higher tendency to connect with each other when they happen to share links with other actors in the network (Snijders, Pattison,

Robins, & Handcock, 2006; Robins, Pattison, & Wang, 2009). Formed by path-shortening strategies or a direct link between unconnected actors sharing a common partner, such a tendency for closure prevents defection more effectively because the parties can better monitor each other's behavior, resolve conflicts through consultations, and impose more effective sanctions on wrong doers (Coleman, 1988). Thus, multiplex closure reduces uncertainty and sustains cooperation in exchange.

Multiplex closure also promotes credible behavior by contributing to building trust and group norms to ensure credible commitments (Putnam, 2000). In the context of project implementation networks, for example, projects that are supported by a more cohesive group of organizations possessing various resources are found to be more successful than projects that are supported by a less cohesive group of organizations because the projects supported by a cohesive group of organizations are able to secure the credible commitment of all the partners (Shrestha, 2013). It is plausible to expect greater prevalence of multiplex closure when two actors engage into multiple relationships with multiple shared partners.

Multiplex closure can take different forms. As shown in Figure 1C, multiplex transitivity in social networks occurs where actors have a tendency to close open two-path configuration because of potential defection by the intermediaries. For example, in intergovernmental fiscal relations, local governments generally maintain direct lobbying or information sharing ties with federal agencies as transfer of federal dollars to local governments through state agencies can be subject to manipulations by the states. On the other hand, when every actor in a group is interlocked with its partner via different ties, a multiplex cyclic closure of generalized exchange type is formed (Figure 1D). Multiplex closure for shared out-ties (Figure 1E) emerges when two structurally equivalent, yet unconnected, cities form closure networks because both share common partners to whom they provide resources. Finally, multiplex closure for shared in-ties (Figure 1F) is formed when two unconnected, structurally equivalent cities create closure networks because both share common partners from whom they receive resources. In both cases, the closure can be achieved by sharing information between the previously unconnected, structurally equivalent actors. Each of these closure mechanisms promotes cooperation by creating social trust and thereby preventing defection. Hence, in general, actors motivated to ensuring credibility of commitment of partners in ICA situations should be more likely to develop multiplex closed, bonding structures.

8. Challenges

Multiplex network analysis poses challenges for scholars at both theoretical and methodological fronts. Theoretically, we need a richer conceptualization of coordination and cooperation mechanisms in ICA settings that can guide our thinking of what structural configurations actors should seek in each type of situation. Further effort is needed to understand how networks are shaped when these problems coexist, as it is rare that a governance system faces one, but not the other, type of problem. Do actors attend to all

problems simultaneously, thus creating both bridging and bonding structures that coexist with each other? Or do they attack problems sequentially, prioritizing one type of relationship over another? If the former is true, are there specific "mixed" configurations that are likely to help achieve both coordination and cooperation? If problems are addressed sequentially, however, what affects the decisions of the actors to prioritize their problems, and how does this affect the sustainability of collaborative practices? Producing answers to these questions will require the concerted efforts of public policy and management scholars.

There are also important methodological challenges to be faced. Even with just two types (formal and informal) of ties, it becomes complex to sort out the various combinations of ties as dependency considerations move from dyadic to triadic and higher levels. The choice of a particular effect will require well-developed theory explaining structural mechanisms for addressing coordination and cooperation problems. While there has been considerable progress in modeling dependencies in multiplex networks (for examples of multivariate exponential random graph model specifications, see Pattison & Wasserman, 1999; Wang, 2013), such modeling is mostly restricted to simple configurations involving only two types of ties.

The approach delineated here can also be applied to multiplex networks of multiple formal networks or multiple informal networks. For example, a city can enter into more than one formal service contracts with another city. Likewise, informal ties between two cities could consist of exchange of information and attending the same professional meetings. In other words, ties have weights too, and this introduces another layer of complexity which needs to be dealt with.

Finally, for reasons of space we have only covered in slight detail how the different configurations indicate bridging and bonding, but more work is needed to clarify exactly in what circumstances actors in a network would prefer to form, say, transitive triadic relationships instead of cyclic triads. The drivers of behavior in these networks will probably be highly contextual, depending not only on the problems that the nodes face, but also on the nature of the links the researcher is interested in studying. Scholars interested in pursuing any of these ideas must be fully aware of these limitations.

9. Conclusion

In this essay, we made a quick case for simultaneous analysis of multiple networks for better understanding of how actors embedded in multiple networks are able to address coordination and cooperation problems in ICA situations. In this regard, we highlighted the origin and challenges of coordination and cooperation problems in ICA settings, and discussed how those problems can be addressed by utilizing bridging and/or bonding capital in multiplex networks.

Notwithstanding the theoretical and methodological challenges, noted above, we believe that the multiplex bridging and bonding network structures advanced in this essay

for solving coordination and cooperation problems serve as a step forward towards more general treatment of embedded relationships in situations where ICA dilemmas take place.

Because of our focus on multiplex networks, we did not highlight the potential effect of single network structures on the multiplex network structures. We also limited ourselves to the discussion of the emergence of multiplex network structures, rather than how these networks impact the outcomes. Investigating the impacts of multiplex networks opens a whole new avenue for research with implications on the management of networks. The current advancement on both theoretical and methodological fronts offers opportunities for scholars to develop and test theory explaining the emergence of multiplex network structures and their impacts. This process should pave the way forward in advancing the complexity science for better understanding of how actors self-organize to achieve coordination and cooperation in real social networks that are multiplex in nature. We urge scholars to join in this collaborative endeavor.

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