

A Typology for Understanding the Connections Among Different Forms of Social Capital

Jennifer L. Glanville

University of Iowa, Iowa City

Elisa Jayne Bienenstock

Georgetown University, Washington, D.C.

Critics have argued that the term social capital is too vague or general to be a useful concept. Recognizing the need for clarification, the authors distill the conceptual discussions about social capital to argue that there are three components—network structure, trust and reciprocity, and resources—that are associated with but vary in degree and salience for all forms of social capital. These three components should be considered continua along which the forms of social capital can vary. A fourth continuum is between micro and macro levels of social capital. Locating particular examples of social capital along these continua opens the possibility to compare different types of social capital and to develop and test theories about how they are related to each other. The authors also describe a simulation study to illustrate how simulation can facilitate understanding of the linkages among different forms of social capital.

Keywords: *social capital; social networks; trust; reciprocity; simulation*

The potential explanatory power of social capital in a wide range of contexts has generated considerable interdisciplinary and public policy interest. Although this broad appeal has the salutary effect of generating interdisciplinary discourse, in many ways social capital researchers from different fields continue to talk past one another. In this article, we address several important conceptual questions regarding social capital and offer a framework for understanding how various forms of social capital are related.

Most writers agree that social capital refers to investment in personal relationships or social structure that facilitates the achievement of individual or collective goals.

Authors' Note: The authors contributed equally. We thank Pamela Paxton, Kenneth Bollen, Charles Kadushin, Kyra Greene, Maurice Zelditch, Joseph Bielitsky, Alan Garfinkel, Michael McBride, and Michael Salwen for helpful comments on earlier versions of this work. We also thank Michael Jacob Mettler for programming the simulations, comments, and suggestions. Correspondence concerning this article should be addressed to Jennifer Glanville, Department of Sociology, W140 Seashore Hall, University of Iowa, Iowa City, IA 52242; e-mail: jennifer-glanville@uiowa.edu.

Given the general nature of this description, it is not surprising that there is a great deal of debate on how exactly to conceptualize and operationalize this concept. Examples of the disparate phenomena labeled as social capital include social networks beneficial in attaining good jobs (Boxman, De Graaf, & Flap, 1991), social support (Briggs, 1998), parental attention fostering children's educational attainment (Teachman, Paasch, & Carver, 1997), and civic engagement (Putnam, 1993, 2000). These examples illustrate the broad range of phenomena labeled social capital: phenomena that exist at different levels of analysis and touch on virtually all aspects of social life.

The conceptual ambiguity of the term has led some critics to question the utility of the concept (Kadushin, 2004; Portes, 1998). Given the continuing broad appeal of the concept, it seems ill advised to cast the concept aside. Instead, we suggest that a more fruitful strategy for handling the ambiguity is to work toward establishing a framework for understanding how diverse forms of social capital might be related. Many common sociological ideas are also very general and used in a myriad of ways yet are widely regarded as useful concepts. In fact, some of the most important sociological concepts are also difficult to pin down to a single meaning. Consider, for example, a fundamental concept such as social structure, which generally refers to a characteristic that is external to the individual but is distinguished from culture and has very specific, yet disparate, meanings for different theoretical traditions. For example, within the field of social networks, social structure explicitly means the pattern of connections among agents. In contrast, Blau and Schwartz (1984) defined social structure as "the extent of differentiation of a population" (p. 8) with regard to demographic and status characteristics. In short, social structure can refer to phenomena as divergent as gender ratios within a group to governmental institutions. And yet it is clear that these phenomena share something—they are external to the individual and yet they influence individual attitudes, behaviors, and outcomes.

As is the case with social structure and many other sociological ideas such as power and status, different instantiations of social capital share commonalities. In brief, we argue that despite the conceptual confusion surrounding social capital, there are three components—network structure, trust and reciprocity, and resources—common to definitions of social capital, though to varying degrees and salience. Furthermore, the different forms of social capital are related and are located along four continua: (a) dense to dispersed social networks, (b) level of trust and/or reciprocity, (c) level of resources, and (d) micro to macro. For example, different types of social network structure and different types of reciprocity will create distinct forms of social capital, which in turn are more or less conducive to particular outcomes. Locating the types of social capital on these continua opens the possibility for seemingly different types of social capital to be compared or for theories to be tested on how they may be related to each other.

In explicating this framework, we draw from other research traditions, particularly social networks and exchange theory. The relevance of social networks is obvious, as for many theorists social networks are almost synonymous with social capital.

Understanding the effect of exchange of resources of different types on trust and reciprocity is one of the main thrusts of exchange theory. Both traditions have grappled with reconciling the micro–macro connection. In particular, we argue that macro or aggregate-level social capital can be thought of as an emergent property of micro-level social capital, and insights from these other traditions combined with computational models provide directions for social capital theorists to investigate this connection.

Below, we briefly describe the conceptual roots of social capital in the work of Bourdieu and Coleman. We then describe the components that are commonly attributed to social capital and explain why the various forms of social capital should be viewed as lying along four continua. Finally, we explore the link between micro- and macro-level social capital using ideas from network and social exchange theories and an illustrative simulation study.

Conceptual Roots

The theoretical origins of social capital are generally attributed to Bourdieu and Coleman, though a number of authors preceded them in using the term. Bourdieu (1986) introduced social capital as a part of his larger project aimed at understanding the perpetuation of inequality. He defined social capital as “the aggregate of the actual or potential resources which are linked to the possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition” (p. 248). According to this definition, the amount of social capital to which an actor has access depends on both the quantity of the network connections that she or he can enlist and the sum of the amount of capital (e.g., financial, human, cultural) that each network member possesses.

Coleman (1988) introduced social capital in an effort to bridge the gap between sociological and economic explanations of social action by showing how explanations based on rational action could fit into a framework that also emphasized the importance of social context. As such, his conception is more general than Bourdieu’s. According to Coleman, social capital is a “variety of entities with two elements in common: they all consist of some aspect of social structures, and they facilitate certain actions of actors—whether persons or corporate actors—within structures” (p. S98).

Notably, Bourdieu and Coleman agree on many fundamental aspects of social capital. First, both identify social capital as something that inheres in social relationships rather than as something that is tangibly possessed by individuals. That is the “social” aspect of the term. Second, both of their definitions treat it as “capital” in the sense that it is fungible and that relationships invested in, whether consciously or unconsciously, provide indirect benefits as a facilitator or means of producing an ultimate “consumable” good. According to both definitions, investment in interpersonal relationships is what creates social capital. Furthermore, for both theorists,

social relations that originate for one purpose can often be appropriated for other purposes. Bourdieu pointed out that obligations that accrued in one context could be translated to others, whereas Coleman observed that social capital is often created as a consequence of other activities.

However, the Bourdieu and Coleman formulations also differ in important ways. First, consistent with their different purposes in introducing the concept, they differ in the phenomena that they use social capital to explain. Bourdieu uses it to explain inequality or how persons and groups maintain advantage. Coleman's focus is more general, explaining a wider range of outcomes including dropping out of high school and participation in democratic social movements. In fact, Coleman's description is general enough to subsume Bourdieu's.

In addition, although for both theorists social capital exists in collectivities, there is a crucial difference in their formulations at this level. In his discussion of social capital at the group level, Bourdieu refers to homogeneous groups that have a unified set of interests. In contrast, Coleman's theoretical discussion does not explore the implications of homogeneity versus heterogeneity for the formation of social capital. An inference one can draw from his discussion is that, for Coleman, social capital can exist in large groups, such as neighborhoods or communities, that have a number of subgroups within them. Furthermore, Bourdieu attributes the activities of interest groups (e.g., elite schools and clubs or cultural events) as efforts to reinforce the consolidation of social capital within more cohesive groups. Coleman does not emphasize the nature of groups as classes or agents that act in ways to concentrate social capital within their boundaries. So although both consider group-level social capital, Bourdieu conceives of it more narrowly in terms of pertaining to homogeneous groups, whereas Coleman does not place such restrictions on which groups might possess social capital.

In a series of articles and books, Robert Putnam's (1993, 1995, 2000) use of the term *social capital* helped spark both its broad appeal and much of the criticism targeted at conceptual ambiguity. According to Putnam (1993), social capital "refers to features of social organization, such as trust, norms and networks, that can improve the efficiency of society by facilitating coordinated actions" (p. 167). He argues that regional levels of social capital account for why the identical government structure functions better in the regions of northern Italy than it does in the regions of southern Italy (Putnam, 1993). He also attributes the decline in American political engagement, as reflected by voter turnout, to a decline in social capital (Putnam, 1995, 2000). Thus, while adopting elements of Coleman's definition, his primary focus is on how social capital, as a public good, influences outcomes at the community, regional, or national levels. Accordingly, Putnam's main focus is on the type of social capital that Coleman argued would develop only as a byproduct of other activities. In other words, Coleman argued that the direct accumulation of this form of social capital is problematic because of the free-rider problems inherent in the emergence of public goods, and, instead, this form of social capital emerges as a byproduct of other pursuits.

The Components of Social Capital

In light of the conceptual ambiguity surrounding the concept, several scholars have proposed ways of clarifying the concept by offering their own definitions of social capital. Many of these definitions are quite distinct from one another (e.g., Adler & Kwon, 2002; Burt, 1997; Lin, 2001; Paxton, 1999; Woolcock, 1998). Because there is no consensus in these definitions on the key components or dimensions of social capital, the proliferation of definitions has compounded confusion over the nature of social capital. In this section, we provide a detailed discussion of the components of social capital in an attempt to assess whether and how these differences can be reconciled.

It is almost universally agreed that networks play a role in defining social capital, though which properties of networks are important is debated. Other than the common recognition of the importance of networks, there is considerable disagreement regarding what other component(s) are requisite in defining social capital. The major division is between definitions that emphasize resource availability versus trust or reciprocity. It is interesting that this difference roughly corresponds to the level of analysis of interest. Those who primarily focus on the benefits of social capital to individuals or small groups (e.g., Lin, 1999, 2001) consider the resources embedded in social networks as an important feature of social capital, with little focus on trust or reciprocity. In contrast, those interested in large aggregates such as communities or nations (e.g., Paxton, 1999; Putnam, 2000; Uslaner, 1999) consider trust and reciprocity integral to social capital and are less concerned about the resources available to members of the social network. Therefore, it appears that a fundamental difference in definitions is related to their focus on phenomena conceptualized at different levels of analysis. However, our examination of the components of social capital suggests that resources and trust are both components of social capital, regardless of the level of analysis.

We argue below that the different types of social capital can be placed along four continua. The continua are (a) dense networks to dispersed networks, (b) level of reciprocity and trust, (c) level of resources, and (d) level of analysis. The potential consequences (both positive and negative) of a given form of social capital depend on its location along these four continua.

Social Networks

Although social capital researchers generally agree that network structure is an important aspect of social capital, they differ on which aspects of social networks they view as important. Within the field of social network analysis, network characteristics identified as important include density, the prevalence of bridges and structural holes, levels of homogeneity, and so on. Different levels or combinations of these characteristics have different implications. In the social capital literature, the term *social*

network often refers to one salient network characteristic relevant to a particular outcome rather than an underlying structure that contains that feature. For example, one debate is whether a dense or dispersed social network is more advantageous. Dense networks are characterized by a set of strong and supportive ties, whereas dispersed networks have ties that bridge social worlds. Coleman emphasized the role of dense networks and intergenerational closure. In contrast, Burt (1997) argued that social networks rich in structural holes characterize social capital.

This differential focus has emerged mainly because researchers use social capital to explain different types of outcomes. Research on outcomes related to social and emotional support tends to emphasize the advantages of dense networks, whereas research emphasizing instrumental outcomes values dispersed networks. In view of this, Briggs (1998) distinguishes between two forms of social capital at the individual level. One form of social capital provides social support, and the other provides access to “leveraging” resources. Similarly, Lin (2001, p. 27) observes that density and social closure are more beneficial for “preserving or maintaining resources,” whereas dispersed networks are more beneficial for “searching for and obtaining resources not presently possessed.”

In the social capital literature the relationship between these two types of social network characteristics is often viewed as zero sum, and, for some researchers, high levels of ego density is considered a positive attribute, but for others it is a negative attribute. In contrast, social network theory recognizes that it is beneficial to have a set of strong ties that are densely connected and still have weak or bridging ties that provide access to diverse social resources, and there are outcomes, such as educational attainment, for which both types of ties could be beneficial (Granovetter, 1973). That different types of network structures facilitate different outcomes implies that if an individual were to act strategically, her or his goal should be to accumulate different types of connections to be leveraged at different times for different situations because she or he might not be able to predict the type of social capital that would benefit her or him most in the future. This “diversified social portfolio” would allow an individual to draw on the appropriate segment of the social network, depending on need.

Trust and Reciprocity

Most researchers regard reciprocity and trust as related to social capital. Some consider trust and reciprocity antecedents of, others consider them elements of, and still others consider them outcomes of social capital. Trust and reciprocity are related concepts, strongly conflated, but not interchangeable. Reciprocity is a norm that requires a return in kind of a good or service rendered (Gouldner, 1960). Definitions of trust generally agree that expectations of good will and acceptance of risk or vulnerability are inherent in the placement of trust (Barber, 1983; Yamagishi & Yamagishi, 1994). Therefore, levels of trust and reciprocity are indicators of the confidence with which people feel free to invest in social relations and institutions.

Accordingly, we argue that social capital cannot exist without some level of trust or reciprocity. Micro-oriented researchers have tended to omit reciprocity from definitions of social capital. Yet consideration of the process through which networks provide access to resources that translate into instrumental gains reveals that trust and/or reciprocity must be present for networks to successfully facilitate this transfer. For example, Völker and Flap (1997) studied the use of ties with neighbors for instrumental support in the former East Germany. They found that under the Marxist regime East Germans were unlikely to invest in relationships with their neighbors, which they attributed to an atmosphere of distrust created by the repressive regime. Even though potentially useful weak ties were available in close proximity, East Germans rarely utilized these potential resources because they did not trust their neighbors. Similarly, Smith (2005) suggests that trust is necessary to activate network assistance in searching for a job. Therefore, although reciprocity is not explicitly incorporated in some definitions of social capital, it must be an implicit component for network ties to be effective.

Bourdieu (1986) explicitly recognized that reciprocity is a critical element of social capital: "The network of relationships is the product of investment strategies . . . implying durable obligations subjectively felt (feelings of gratitude, respect, friendship, etc.)" (p. 250). He portrayed the accumulation of social capital as the result of conscious and unconscious long-term investment strategies designed to establish or maintain relationships of perceived obligations that can be accessed on some future occasion. Resources will not be provided by network connections unless they have been accumulated over a long period of time in relationships that have been established "as if for their own sake" (p. 252). Thus, Bourdieu indicates that social capital cannot exist without subjectively felt obligations and the expectation of reciprocity.

An important and open question is how reciprocity and trust are related. Although there is consensus that they are related, there is disagreement about how. For economists and some sociologists, including Coleman, trust is a precursor to reciprocity; without an underlying institution or social structure that guarantees trust, a person would hesitate to transfer control over a valuable resource to another, which is required to initiate reciprocity. For anthropologists and exchange theorists, on the other hand, the level of trust is a consequence of experience with reciprocity. People who risk exchange and garner a reciprocal response learn to trust that reciprocity is likely, whereas those who risk exchange and are disappointed do not.

Furthermore, exchange theorists distinguish among different types and levels of reciprocity that are considered antecedent to different levels of trust. The most basic type of reciprocity, direct reciprocity, is a simple quid pro quo between two people. At the other end of the spectrum is indirect, or generalized, reciprocity, which is used to explain phenomenon such as altruism among strangers.¹ Lévi-Strauss (1949/1969) distinguished generalized reciprocity from direct reciprocity to explain the kinship patterns he had observed, patterns that could not be explained by restricted reciprocity. Indirect or generalized reciprocity is present in groups of three

or more where an actor who benefits someone does not expect to have this reward reciprocated by the particular actor she or he assists but by someone else who takes part in the exchange situation.

The type of reciprocity and exchange that predominates in a group has important implications. For example, Lévi-Strauss (1949/1969) found that groups where generalized exchange predominated had higher levels of solidarity than did groups where restricted exchange was more prevalent. The implications for trust differ for these different types of reciprocity. Direct reciprocity may garner only local trust, a trust of the other person involved in the exchange. Indirect reciprocity may result in a greater generalized trust. Experience with direct reciprocity may also generate generalized trust when the experience is frequent, consistent, and repeatable with many partners, especially if there is some public character to the direct exchange, such as the availability of witnesses or the dissemination of information on reputation.

Resources

Many social capital theorists emphasize the importance of the resources embedded in social networks, though the nature of what constitutes a resource is not always clear. The resources Bourdieu (1986) has in mind are the other types of capital (financial, cultural, etc.), some of which are material and some of which are not. Lin (2001) has provided a useful discussion of what constitutes a resource: "Social resources may include material goods, such as land, houses, car, and money and symbolic goods such as education, memberships in clubs, honorific degrees, nobility or organizational titles, family name, reputation, or fame" (p. 43). However, financial or socioeconomic resources are the most common ways in which this aspect of social capital has been operationalized.

According to some, social capital is largely absent when there are few resources available through the social network. Yet socioeconomic resources are not important to all outcomes that are associated with social capital, whereas some level of trust and reciprocity is. For example, during a serious illness, ties to persons who feel obligated to help out are necessary for receiving (unpaid) assistance. Consider also the residents of "the Flats," the impoverished community observed by Stack (1974). The Flats' residents were able to cope with poverty by embedding themselves in dense networks of reciprocal obligations. Through exchanges such as child care for food, these reciprocal obligations enabled day-to-day survival of the Flats' residents.² Of course in both examples, resources could also be beneficial because persons with higher levels of resources may be in a better position to provide financial assistance or take time off of work to help a friend in need.

Thus, we view resources as a dimension along which a particular form of social capital could be located. Having access to persons with high levels of resources is certainly advantageous. For example, research has suggested that the socioeconomic

status of network ties is influential in employment-related outcomes (Campbell, Marsden, & Hurlbert, 1986; Lin, Vaughn, & Ensel, 1981). However, networks with relatively small amounts of resources can be beneficial in other ways. Resources might affect the level of payoff that one gets from investing in interpersonal relationships, but it is virtually impossible to imagine a tie or a network that possesses reciprocity to be completely useless for *any* type of outcome. Blau (1964) pointed out that some relationships are formed because of the intrinsic value inherent in the tie, whereas others are formed because of some benefit extrinsic to the relationship. Although there can be value inherent to ties, it can be argued that additional incentives or resources add to the value of the connection. Consequently, the level of resources is another dimension along which the forms of social capital can vary.

Level of Analysis

One of the most important issues surrounding the conceptualization of social capital concerns the proper level of analysis. Several commentators have been skeptical of the use of social capital as a macro-level concept (e.g., Astone, Nathanson, Schoen, & Kim, 1999; Portes, 1998). For example, Portes (1998) argues that sociological studies of social capital “have been grounded on relationships between actors or between an individual actor and a group” (p. 17) and that “the greatest theoretical promise of social capital lies at the individual level” (p. 20).

Commentators have argued, for example, that macro-oriented social capital research ignores the fact that in many communities, individuals do not have equal access to social capital (Astone et al., 1999; Edwards & Foley, 1997). Although this is an important consideration, individuals with limited access to social capital but who reside in high social capital communities still benefit in some ways. Consider a neighborhood with a relatively high level of connections among residents. There are some residents of the neighborhood who remain relatively isolated from their neighbors, and accordingly they are unable to rely on neighbors to water their plants while they are away, go out of their way to provide information or influence in their job searches, and so on. However, even these relatively isolated residents will benefit from an increased level of safety. In addition, other collective outcomes such as economic development and democratic governance are potentially important for all of the individuals that compose them, even if some benefit more from social capital than do others.

The objections to employing social capital in research targeted toward collective levels of analysis may be more properly understood as concerns about the ways in which many macro-level studies have been implemented rather than as an outright dismissal of the existence of macro-level social capital. As Portes (1998, 2000) has argued, there are several conceptual and methodological pitfalls to which macro-oriented research

on social capital has been vulnerable. These pitfalls include a lack of conceptual clarity regarding the nature of social capital, circular reasoning that conflates causes and consequences, and a lack of attention to other possible explanations that could account for observed relationships. Furthermore, Astone et al. (1999) argue that studying social capital as an attribute of a group distracts attention from the reasons why individuals invest in social capital in the first place. Most of the serious criticism of social capital emerges when the definition becomes so inclusive that there is little or no affiliation with the original definitions of Bourdieu and Coleman, who made it clear that social capital derives from investment in interpersonal relationships.

Despite the caveats that have been raised, further inquiry into macro-level social capital is important sociologically. Rather than disregarding work focused on the macro level because it is difficult to detangle interrelated components, the focus should be to try to understand the emergence of social capital as a collective attribute. Much more conceptual and empirical work on the nature of social capital as a macro-level variable is needed. The connection between micro and macro social structure has been a long-standing interest in sociology, and Coleman viewed social capital as a useful way of understanding this connection (also see Baker & Faulkner, 2009 [this issue]). In his words, social capital provides “an aid toward making micro-macro transitions” (Coleman, 1988, p. S101). Viewed structurally, the patterns of micro-level social capital to which individuals have access contribute to what constitutes social capital at the macro level. To achieve a high degree of community social capital, at least some proportion of individuals in a community needs to be embedded in networks that are reciprocal. At the same time, patterns of macro-level social capital influence the degree to which individuals will invest in social capital. For example, Sampson (1988) finds that at the aggregate level a sparse network within a neighborhood inhibits opportunities for persons to form or maintain ties with neighbors.

Although micro and macro levels of social capital seem to be related somehow, this linkage deserves careful consideration. The processes through which micro interactions get translated into larger social structures and how larger structures influence these interactions are not well understood. Clearly, there is not a direct process through which social capital at the micro level gets aggregated into macro-level social capital, such that the more micro-level social capital there is within a community, the more there is at the aggregate level. Such a simplistic theory is clearly problematic.

Several examples make it clear that the *distribution* of micro-level social capital is fundamental in determining the type and level of community social capital. For example, Granovetter (1973) suggests that the “urban villagers” studied by Gans (1962) were unable to organize against the urban renewal project that destroyed their neighborhood because of how the micro-level patterns of social networks in a community coalesced into a neighborhood-level network with a low capacity for collective action. Because the urban villagers’ social relations were largely confined to densely connected groups of strong ties, they did not have ties that bridged the

neighborhood cliques, which would have facilitated the development of successful collective action. In a study of ethnic conflict in India, Varshney (2002) finds that villages where voluntary associations are composed of both Hindus and Muslims, rather than being ethnically homogeneous, had much lower interethnic violence. Paxton (2002) observes that a higher rate of participation in voluntary associations that are crosscutting is positively associated with democracy, whereas participation in voluntary associations that are isolated from other associations is negatively related to democracy. These findings strongly suggest that an examination of the distribution of micro-level social capital would be highly fruitful in understanding the formation of macro-level social capital that can benefit the collective.

We also suggest that simulation studies offer a rare opportunity to witness the translation between micro and macro forms of social capital. Simulations that are informed by social exchange theory are particularly promising. Since its inception, exchange theory has considered micro-level interactions and exchanges antecedents of macro-level institutions. Blau (1964) and Homans (1961) posited that interaction at the micro level had macro-level implications whereas macro-level factors such as community-wide levels of trust affected micro processes indicating a dynamic feedback system. After providing some illustrations of the how outcomes flow through the four dimensions of social capital in the following section, we then describe a simulation study that provides insight into the generation of macro-level social capital.

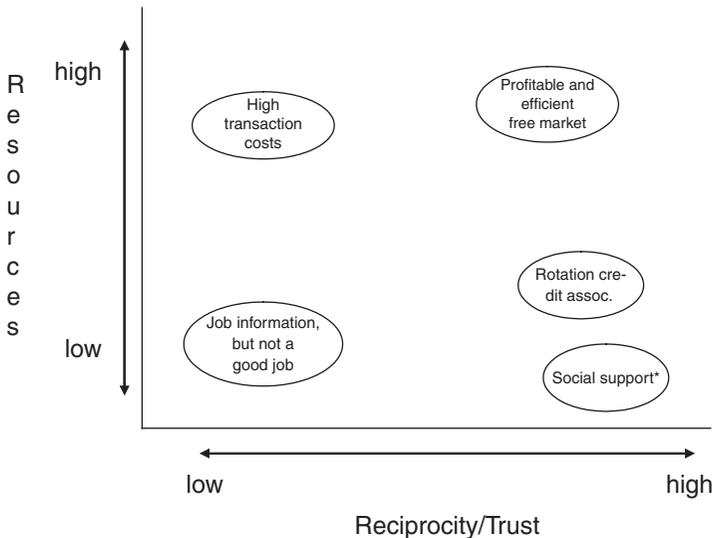
Example Mapping to Conceptual Continua

One benefit of conceptualizing social capital across these four continua is that we are able to see how outcomes flow through the continua. The two figures we describe below provide illustrations of this framework. The figures map two dimensions for the sake of visual simplification. Any combination of the dimensions could be mapped.

Figure 1 demonstrates how the forms of social capital along the continua of low to high resources and low to high reciprocity and trust foster different sets of outcomes. When resources are high but trust and reciprocity are low, transactions costs are high. When both components are high, markets are efficient. When trust and reciprocity are high but resources low, a person might have friends or family who provide her or him with information about a job, but it is unlikely that the job will be a good one. Social support will be provided in networks high in trust and reciprocity, regardless of the level of resources. The success of rotating credit associations is dependant on high levels of trust and reciprocity, but only a relatively low level of resources is necessary.

Figure 2 illustrates how the forms of social capital along the continua of micro to macro and dense to dispersed social networks are associated with different consequences.

Figure 1
Outcomes Associated With Forms of Social Capital
for Levels of Reciprocity and Trust Along the Resources Continuum



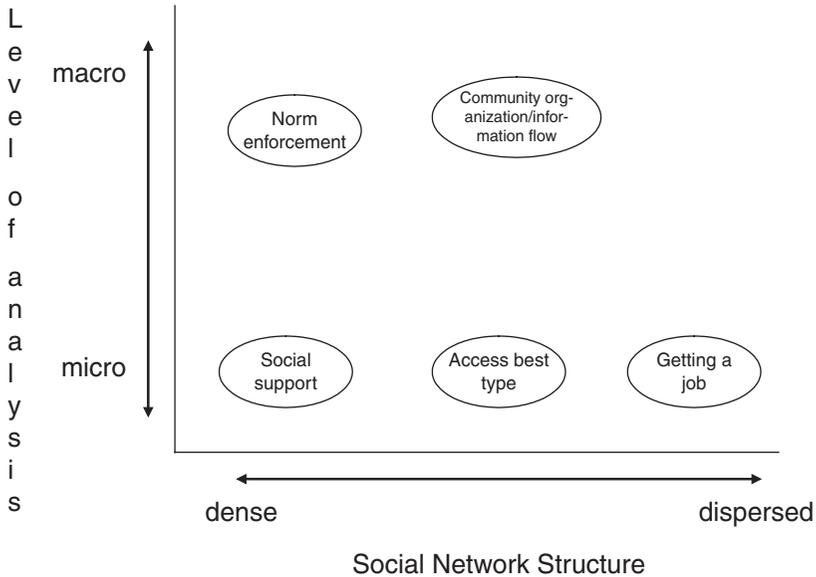
*Social support could be placed anywhere along the right side.

Dense networks can result in higher social support at the micro level and, as Coleman argued, norm enforcement at the meso and more macro levels. At the other end of the network continuum, at the micro level, dispersed networks are particularly adept at accessing new information, for example, information about a job, whereas at the macro level they facilitate markets and the free flow of information as in the Internet. Social network structure in the center of the continuum may be the most beneficial at both the micro and macro levels. For individuals, a network rich in bridging ties that also has dense portions may provide the best of both worlds in that individuals can access different types of ties, depending on their needs at the particular moment. As the small world literature indicates at the macro level, local interconnectedness combined with bridging ties between groups is advantageous (Watts, 1999). Similarly, Burt (2001) finds that closure within work groups intensifies the performance benefits of structural holes.

An Illustrative Simulation Study

Theoretical approaches that link micro and macro behaviors, and the latter to be emergent from the former, are difficult to empirically evaluate because it is not

Figure 2
Outcomes Associated With Forms of Social Capital
Along the Micro–Macro and Social Network Continuums



possible to directly investigate the causal connection between individual behavior and macro structure. Recently, however, computational models have demonstrated how choices regarding interactions at the micro level can generate different macro-level environments, which in turn affect decisions for the subsequent behavior of individuals. Agent-based modeling is a simulation technique that allows theorists to study emergent macro-level outcomes by programming large populations of simulated actors, referred to as agents, each with very simple characteristics, and observing their interactions. The output of this type of modeling permits researchers to compare, contrast, and experiment with different sets of actor characteristics and rules of interaction to link sets of assumptions at the micro level to characteristics of macro systems or societies. Although this work has not directly addressed how micro and macro concepts of social capital are linked, much of the prior work focused on factors identified as fundamental to social capital: reciprocity, trust, and macro-level structures that facilitate the good faith exchange of resources.

The model we present below is a preliminary step toward understanding the conditions under which micro-level interactions can lead to a high level of

macro-level cooperation that, for example, might sustain democracy or encourage economic development. In addition, it illustrates how simulations can be used to test hypotheses regarding how the components of social capital interact. This model explicitly incorporates networks and demonstrates how networks act to generalize reciprocity by allowing rewards and sanctions of undesirable behavior to be administered indirectly. Networks allow reputational information to spread, which in the short run allows sanctions of “noncooperative” behavior but in the long run produces environments where noncooperative behavior is rare, providing an environment where the expectation of reciprocation is reasonable, which can be thought of as a simple form of macro-level social capital. Accordingly, the model is a first step to demonstrating that when networks support indirect reciprocity, by facilitating the spread of reputational information they allow for the emergence of “generalized” trust, which facilitates cooperation.

The study we describe is an evolutionary model of cooperative behavior. An evolutionary model begins with an initial population of programmed entities called agents that interact with each other or the environment, based on simple rules. In this study agents differ based on the strategies they use to determine whether to act cooperatively when paired with another agent. In an evolutionary model, agents that amass the most resources reproduce at a higher rate than do less successful agents, and, accordingly, later generations of the population will be mainly composed of agents with successful strategies. In this way agent decisions affect the makeup of the environment and in this example demonstrate how social networks enable micro-level reciprocity to evolve into macro-level breeding grounds of cooperation.

Previous work in evolutionary game theory demonstrated that, in situations both political (Axelrod, 1984; Dugatkin, Mesterson-Gibbons, & Houston, 1992) and biological (Axelrod, 1997), cooperation emerges when direct reciprocity and punishment are possible. That is, when two selfish actors engage in *repeated* interaction, cooperative aggregates can emerge. Repeated encounters between the same partners provide opportunities for actors to retaliate or reward their partner’s behavior. When direct reciprocity is not possible (as in large social systems where the likelihood is small that two actors will be paired twice is low), actors can defect with impunity, providing little incentive to cooperate (Alexander, 1987). These findings imply that high levels of social capital are unlikely to emerge in large populations because direct interaction is not likely. However, empirical studies show that, in fact, macro-level social capital often flourishes in large populations (Putnam, 2000).

Thus, the question remains, what factors are vital to support macro-level social capital? Alexander (1987) posited that in the absence of direct reciprocity, *indirect* reciprocity might foster cooperation. Boyd and Richerson (1989) demonstrated that indirect reciprocity is sufficient to bring about cooperation in *small* social systems. By allowing good deeds to move through a circle of agents in one direction, their simulation provided no opportunity for direct reciprocity yet succeeded in generating

cooperative environments when exchange cycles were small (populations less than or equal to 16). For indirect reciprocity to work in *large* populations, however, there must be a measure of an agent's prior behavior (Epstein & Axtell, 1996). Nowak and Sigmund (1998a, 1998b) induced cooperation in large populations by introducing an "image score," which is a tally of an agent's decision history available to all other agents. They found that reputation, measured by image score, facilitates the emergence of cooperation, or at least the containment of defectors, in conditions where direct reciprocity is not possible. When agents were aware of the image scores of only some but not all others, cooperation was achieved only in very small populations (fewer than 11 agents). These studies imply that sustaining community-level social capital would be difficult unless there was a realistic way to transmit information about reputation.

Introducing social networks as a mechanism for generating reputation allows us to demonstrate how varying network structure and level of indirect reciprocity affects cooperation at the macro level. In this simulation, networks are a conduit of reputational information that provides a means to trust. In the real world, reputation is not a signal carried by an individual that strangers can use to distinguish nice people (Macy & Skvoretz, 1998); it is a collective assessment of an actor that emerges from others. Modeling reputation as collective information about prior behavior transmitted by others is intuitive and allows decision-making actors access to information about partners from prior alters they have reason to trust rather than taking a leap of faith that the signal emitted from a stranger can be trusted. Information networks, once established, allow those individuals in the network both a way of accessing information about potential partners and a means of advertising their own prior good works.

Our simulation models the following situation: Two strangers meet and determine whether they have any common acquaintances. If the meeting is a prelude to a transaction, each person "checks up on" her or his new partner by contacting common acquaintances and asking for recommendations. In this way, people use social networks to ascertain if new associates are trustworthy. To model this behavior, memory and communication between actors are necessary so that actors can share information about their experiences with selected others. Information sharing within a network allows a collective memory to form within a group, modeling how reputation affects the spread of cooperation.

The Prisoner's Dilemma Game

The prisoner's dilemma is a popular model for evolutionary game theory because it is a simple representation of a situation in which a person must decide between doing what is best for herself or himself and taking a possible loss to do what is best for a collective. The outcomes for each prisoner are contingent on the decisions of both partners.³ Independent of the choice of the partner, each player does better if

she or he defects rather than cooperates; however, the reward for mutual cooperation is better than the punishment for mutual defection.

In this model, agents representing different strategies are paired randomly and with replacement. Initially, two agents are paired, each decides to either cooperate with or defect on her or his partner, and payoffs are recorded. Each is then available to be paired again, with a new partner. After a predetermined number of pairings for the entire population, one generation, the cumulative payoff totals of each agent, divided by the total for all agents, are scaled to the desired population number to determine the initial population distribution in the next generation. Those that amass the most resources are the most fit. Agents representing strategies that are not good at accumulating resources become extinct, leaving a higher proportion of the more successful strategies to interact in the next generation.

Agents in this study represent seven strategies (t) that differ in their tolerance of defectors. These strategies were introduced by Nowak and Sigmund (1998b) to test the effect of image scores on the evolution of cooperation. Strategies range from the value -3 to 3 , corresponding to the point at which an agent defects depending on information available to her or him about her or his partner. Reputation (r) is the sum of the prior actions for each agent that are available to her or his partner (cooperation = 1 , defection = -1). Agents can access information about their partner's prior behavior in two ways: directly, when they have been paired together before, or indirectly, through information received via their social network, composed of common past partners. If for agent i , $t = -3$, for example, i would cooperate with a partner j , unless i is aware that j has defected three times more than j cooperated. A strategy with $t = 0$ donates in the absence of negative indication but must be aware of at least as many cooperative acts as defections. Agents with a strategy of 2 only cooperate when they have been informed that their partner has cooperated 2 times more than defected. Agents compare their partner's reputation (r), measured as the tally of available information about their partner's previous decisions, to t . An agent, i , only cooperates with j if $t_i \leq r_j$.

Building Friendship Networks

In this model, two relations, acquaintanceship and friendship, are generated from the agent encounters. To model networks, a history of associations is recorded along with the cumulative payoff to agents. This history is recorded in two $N \times N$ matrices where rows and columns represent agents. The first is an affiliation matrix, $\mathbf{A} = [a_{ij}]$, where the ij^{th} entry is the number of encounters between agents i and j . \mathbf{A} is symmetric. The second is the cooperation matrix, $\mathbf{C} = [c_{ij}]$, where the ij^{th} entry is the number of times i has cooperated with j . Note that \mathbf{C} is not symmetric. \mathbf{A} is the acquaintanceship network. Any agents who have encountered each other have a direct connection, which means they have memories of their encounter. \mathbf{A} does not represent the friendship (communication) network, which for this simulation is the set of

agent pairs with a prior history of mutual cooperation ($c_{ij} \neq 0$ and $c_{ji} \neq 0$). In other words, “friends” are those within the network who the focal agent has reason to trust.

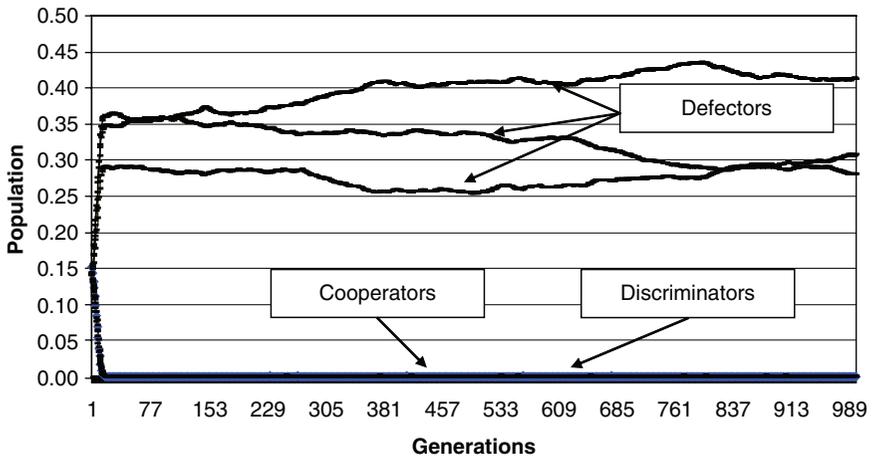
When an agent encounters a new partner, she or he uses information from her or his memory and provided by her or his network before selecting her or his strategy. First, she or he searches her or his memory and the memory of the other agent to determine if they have shared common alters. If they do have common alters these may act as sources of information for one or both partners. For instance, if agent_{*i*} and agent_{*j*} both had a prior encounter with agent_{*k*}, and if the outcome for the encounter between agent_{*i*} and agent_{*k*} was a mutual cooperation, then agent_{*i*} will receive information from agent_{*k*} regarding her or his knowledge about the prior behavior of agent_{*j*}. If the outcome of the encounter was anything but a mutual cooperation, then agent_{*i*} does not receive any information about agent_{*j*}. In the event of multiple encounters or multiple common alters, the number of encounters and the average of the outcomes are communicated to the agent. In this way, agent_{*i*} is able to draw on social capital, if available, in making the decision whether to cooperate or defect with agent_{*j*}.

Results

Building networks that produce and sustain cooperation requires many pairings because networks are not viable until cooperative agents have friends with whom to communicate. The probability of the pairing of two cooperators is small. For example, if the population (N) is half cooperators and half defectors, four pairings are needed for the average cooperator to have one friend. Having one friend is not sufficient to produce cooperation; thus, it is necessary for cooperators to have several friends before they have a strategic advantage. In addition, it takes several more pairings for the strategic advantage to undo the fitness advantage already acquired by defectors. Large numbers of pairings make occasional repeated encounters inevitable; however, a large number of repeated pairings is insufficient to generate a population of cooperators based only on direct reciprocity. A simulation allowing 100 agents to access their own memories of prior encounters with alters but not allowing communication with friends illustrates this. The results presented are averages for 1,000 iterations of the simulation with a population of 100 and 1,400 pairings and 1,000 generations. Figure 3 shows that defection quickly proliferated and that $14N$ pairings is insufficient to generate cooperation based on direct reciprocity.

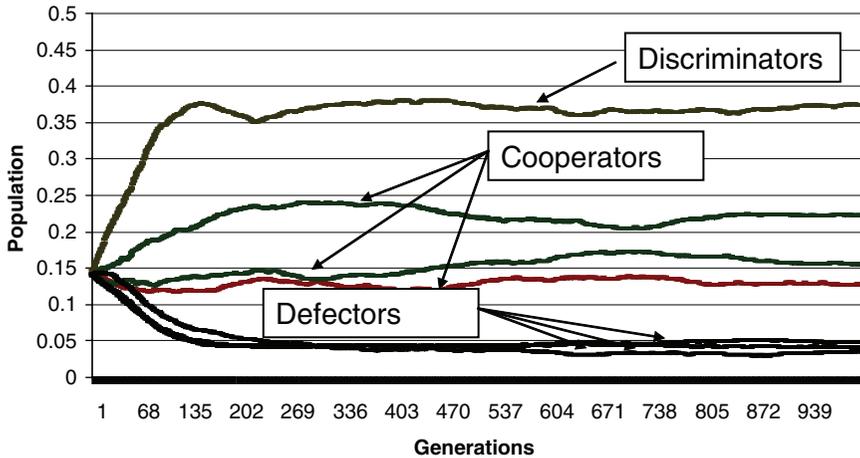
In contrast, allowing friends to communicate information about a former partner’s behavior results in an advantage to cooperative strategies (see Figure 4). The simulation converged most often on Strategy 0, the most discriminating cooperative strategy. Although defecting strategies were the least successful, among cooperative strategies, the more discriminating, the more fit.⁴ The more discriminating cooperative strategies likely most closely represent trusters in the real world

Figure 3
Survival Rates of Different Strategies
for the Direct Reciprocity Condition



because surveys suggest that “high trusters are no more gullible than low trusters” (Rotter, 1980, p. 4), and experiments suggest that trusters readily adjust their expectations of another person in the face of negative information (Yamagishi, Kikuchi, & Kosugi, 1999). The advantage of discriminating cooperative strategies, much like the success of “tit for tat” (3) and other successful strategies (Nowak & Sigmund, 1993) in repeated games can be attributed to their resistance to exploitation. This model suggests not only that cynical cooperation is a successful strategy for dealing with strangers but also that cynical cooperators are important to the population of strategies because they enforce cooperative norms in the population by keeping the defecting strategies at bay, allowing the cooperative strategies to flourish. Because the norm emerges from the encounters rather than being imposed by the programmer, there is no problem with the second order prisoner’s dilemma. Enforcing the norm in this simulation does not have a cost. In fact, the enforcers are benefited intrinsically by their norm-enforcing behavior. The advantages to the agent society are apparent in that the community of agents with a higher proportion of cooperators produces more resources than a community of defectors. The emergence of a norm of cooperation is reminiscent of social capital in that members of the community can feel “safe” in cooperating because the risk of being taken advantage of by a defector is reduced by the emergent structure, which encourages even more cooperative and thus profitable behaviors.

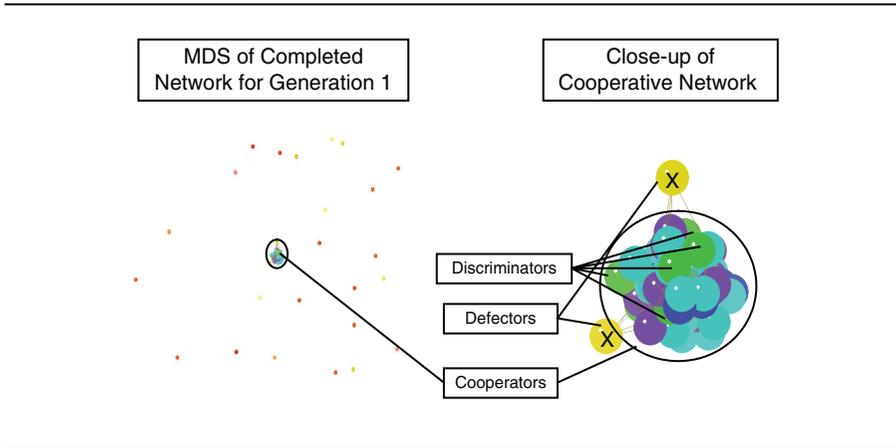
Figure 4
Survival Rates of the Different Strategies for the Network Condition



The network in Figure 5 illustrates the structure of the networks that form in the networked version of the simulation from a randomly selected data set at the end of a first generation. A core–periphery structure, partitioned so cooperators and discriminators make up the core of the network and defectors are marginalized and isolated in the periphery, characterizes the structures that form. The exclusion of defectors from the network reduces the payoff of their exchanges. A closer look at the core reveals that in fact some defectors (moderate defectors = 1) do occasionally join the core and can benefit by receiving information about future trading partners. A single instance of direct reciprocity is sufficient to provide an opportunity for cooperation, which is communicated through the network. Once an agent cooperates and receives information about others, she or he has more opportunities to cooperate, improving her or his reputation and providing opportunities to accumulate resources.

The significance of this simulation for macro-level social capital depends on whether the same results hold in much larger population sizes. Therefore, a modification was to increase population size. Prior work that generated cooperation from indirect reciprocity reported limitations because of population size (Boyd & Richerson, 1989; Nowak & Sigmund, 1998a). To elicit cooperation as population size increases, the number of ties per agent must also increase. For a population of 10,000, $140N$ pairings was sufficient to produce cooperation. Although this might seem like a large social network, a recent estimate found that the average person knows 290 people by sight or name (Killworth, McCarty, Johnsen, Shelley, & Bernard, 1998), which would support cooperation in a population of 40,000 individuals. Furthermore, the network

Figure 5
Visualization of Agent Network at the End of Generation 1



structures generated in this simulation lack some of the characteristics identified in real human networks (Watts, 1999), which would make the transmission of reputation more efficient than these very rudimentary networks.

Discussion and Conclusions

Despite widespread skepticism regarding the utility of the concept, research employing social capital has continued to proliferate. Hence, the broad appeal overshadows the concerns. Consequently, we suggest that the field would benefit from more attention to the connections among different forms of social capital. In reviewing various definitions of social capital that have been proposed, we find that three components characterize social capital: network structure, trust and reciprocity, and resources. The different forms of social capital are related and can be located along four continua: (a) dense to dispersed social networks, (b) level of trust and reciprocity, (c) level of resources, and (d) micro to macro. Furthermore, we provide an example to show the potential for simulation studies to tie these continua together.

The results of the simulation described here suggest that social networks enable the spread of indirect reciprocity. In the absence of direct reciprocity and punishment, agents who cooperate in earlier interactions reap the benefits later, whereas uncooperative agents are punished. Given that the pairings are randomly assigned and consequently the networks introduced at the beginning of each generation are characterized by dispersed ties, the results suggest networks can generate a high

level of cooperation even in communities that are not characterized by dense, tight-knit networks. In addition, social networks allow cooperation based on indirect reciprocity to be sustained even in large populations. Although people do engage with strangers, random, anonymous, and/or atomistic encounters are rare (Granovetter, 1985). People are embedded in social structures, so even when two people do not directly know one another, there is a chance that they know someone who knows someone who does. With only an estimated six degrees separating all the people in the world (Travers & Milgram, 1969; Watts, 1999), it is likely that networks allow for the enforcement of norms of indirect reciprocity.

The simulation study described above is merely a preliminary step. Although the concept of social capital is more complex than indirect reciprocity, the findings of these simulation results for social capital research are informative. Future social capital research could build on this and similar work and design agent-based experiments that directly test many other important questions. For example, although the present study considered only two degrees of separation (acquaintances of friends), network models that extend beyond two degrees, allowing agents to ask for recommendations from friends of friends (three degrees of separation), could assess the degree to which the emergence of cooperation accelerates under these conditions.

Further simulations could test the links between micro- and macro-level social capital in other ways. For example, models could incorporate social network structures that more realistically approximate the real world, such as incorporating cliques. Such work would garner insight into how the distribution of micro-level social capital influences the emergence of macro-level structure. In addition, resources could be added to the model to examine the macro-level implications of inequality in the distribution of resources.

Other agent-based simulations could be used to examine the relationship between trust and reciprocity. As we noted earlier, which comes first is a chicken and egg question. Simulations may suggest that high initial levels of either can produce the other, or they may suggest that one is more likely the source of the other. Simulations would also be useful in understanding the connections between direct versus indirect reciprocity and specific and generalized trust. Theorists could evaluate whether direct reciprocity can lead to generalized trust under specific conditions, or whether indirect reciprocity is necessary. Although simulation studies are certainly not the only avenue for exploring the connections between social capital across these continua, they are a promising way of addressing many key questions.

Notes

1. Parallel to the distinction between direct and indirect reciprocity, Yamagishi and Yamagishi (1994) distinguished between "knowledge-based trust," trust in a specific person known by the actor, and "general trust," which extends to persons not directly known by the actor. For example, trust can be extended to persons who belong to certain groups, such as a particular religion, or it can be extended even more generally to most or all people.

2. The tendency of this type of social capital to deter individuals from taking advantage of rare opportunities for mobility by discouraging the formation of ties outside of the group has been described as a “downside of social capital” (Portes & Landolt, 1996).

3. The payoffs selected here are typical for the prisoner’s dilemma game (Dugatkin, Mesterson-Gibbons, & Houston, 1992): 0 = sucker’s payoff (ego cooperates; alter defects), 1 = punishment for mutual defection, 4 = reward for mutual cooperation, and 5 = temptation to defect (ego defects; alter cooperates).

4. Similarly, Lomborg (1996) found that cautious cooperators are a necessary “shield” against exploitative strategies and enhance the stability of cooperation.

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Jennifer L. Glanville is Associate Professor of Sociology at The University of Iowa where she studies the influence of involvement in voluntary associations on trust and social network structure. Other current research examines the influence of different forms of social capital on educational achievement.

Elisa Jayne Bienenstock is an Adjunct Professor in the Department of Human Science at Georgetown University and Chief Human Science Officer at NSI Inc., where she applies formal models such as social networks and game theory to national security issues. Her current research focuses on developing empirically based computational models of power, status, inequality, and coalition formation with particular emphasis on emergent properties of exchange.