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Production of Collective Action in Alliance-Based Interorganizational Communication and Information Systems

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Abstract

This article presents a public goods-based theory that describes the process of producing multifirm, alliance-based, interorganizational communication and information public goods. These goods offer participants in alliances collective benefits that are (a) *nonexcludable*, in that they are available to all alliance partners whether or not they have contributed, and (b) *jointly supplied*, in that partners' uses of the good are noncompeting. Two generic types of goods produced are *connectivity*, the ability of partners to directly communicate with each other through the information and communication system, and *communality*, the availability of a commonly accessible pool of information to alliance partners. Four types of alliances that can produce these goods are identified: (a) precompetitive, (b) competitive, (c) joint value creation, and (d) value chain. The article examines a variety of factors that influence the production of alliance-based connective and communal goods. Twenty-three integrated propositions are presented. The article concludes with an example of the application of the theoretical model to research on connectivity and communality provided through an alliance-based interorganizational communication and information system linking more than 50 alliance partners.

(Alliances; Communality; Communication; Connectivity; Information Systems; Interorganizational Communication; Public Goods)

Production of Collective Action in Alliance-Based Interorganizational Communication and Information Systems

In a recent special research forum on alliances and networks, Osborn and Hagedoorn (1997) overviewed three major perspectives that have been employed to examine strategic alliances and networks: economics, corporate strategy, and interorganizational fields. Economics-based views included transaction cost analyses, R&D collaborations, and international business foci. Importantly, public goods theory (Samuelson 1954) was not included as an economic perspective that holds potential for explaining the formation and maintenance of strategic alliances. Similarly, it was not included in the compendium of theories proposed by Smith et al. (1995) to explain intra- and interorganizational cooperation. Yet, public goods theory has a long and distinguished history in both the economics and sociology of collaboration (Hardin 1982, Marwell and Oliver 1993, Olson 1965, Sandler 1992), with intellectual roots in the works of Locke, Hume, Adam Smith, and John Stuart Mill. Indeed, Golden (1993) argues that the core issue in many alliances is creating a common good such as a communication infrastructure, either as a means to other ends or as an end in itself. Kumar and van

Dissell (1996) further argue that interorganizational information systems constitute the essential infrastructure on which strategic alliances are built, and typically do so in the form of public goods. Thus, the omission of public goods theory from the discourse on strategic alliances is surprising given its relative success in predicting the formation and continuation of a variety of socio-economic phenomena (Marwell and Oliver 1993). For example, the United Nations is an important alliance that exhibits the behavior of a public good, and collective action through trade unions has also been modeled using public goods theory (Kelly and Kelly 1994). The purpose of this article, then, is to fill this theoretical void by explicating public goods theory for strategic alliances, with a specific focus on creating the good through contributions to interorganizational information and communication infrastructures.

It is important at the outset to distinguish public versus private *goods* from the related notions of public versus private *economic sectors*. The distinction between public and private sectors is between public and private ownership and the property rights attached. However, a "public" or "collective" good, whether it is in the public or private sector, is anything that results from collective action by interested parties that possesses two defining characteristics. First, *impossibility of exclusion* means that members of the collective cannot be excluded from using the good even if they do not contribute to it (Barry and Hardin 1982). Second, *jointness of supply* means that one person's use of the good does not diminish the level of good for other users (Hardin 1982, Head 1972, Olson 1965, Samuelson 1954). A key problem in the production of public goods is "free-riding" (Hardin 1968, Olson 1965, Sweeney 1973), where people enjoy the benefits of a public good without contributing to its establishment and/or maintenance.

By these two criteria, many public goods can be created through alliances in both public and private sectors. A private sector example is the SEMATECH alliance among semiconductor manufacturers. One goal of SEMATECH was to improve industry infrastructure at the national level to counter foreign competition (Browning et al. 1995). The functionality provided by the new infrastructure was *inclusive* in that it benefited all domestic participants regardless of whether they contributed resources to the SEMATECH venture. Indeed, a small number of "free rider" firms benefited without contributing at all to the cooperative (Browning et al. 1995). The infrastructure benefits were also *jointly supplied* in that they were neither consumable nor did partners' use of the infrastructure reduce the amount available for others. The formulation developed in this article focuses on public

goods that meet these two criteria for both private and public sector alliances.

From an evolutionary perspective it is also worthwhile to distinguish between two stages of public goods development: (1) the *production* or creation of a public good, and (2) its *distribution* or maintenance. Traditionally, the public goods literature has focused more heavily on production of public goods, primarily on the incentives required to induce a group of people to contribute their resources to the creation of public-sector public goods such as parks and libraries (Marwell and Oliver 1993). Key dilemmas exist in the production of these goods because the incentive structure that arises from impossibility of exclusion tends to reward noncontributors. This makes public goods difficult to create in the public sector without external inducements. Fulk et al. (1996) provide an example of a public/private sector organizational alliance designed to produce a public-sector public good in the form of organized efforts to combat pollution of public beaches. The incentive structure favors free-riding because all citizens have access to the cleaner beaches without having to help in the clean-up process. In the realm of information and communication goods, the functionality provided by the Internet is a recent example that has been modeled as a public good. It is generally recognized that without the substantial resource contributions of the National Science Foundation in creating the initial infrastructure, the Internet could not have developed as quickly, or perhaps at all.

By contrast, applications of public goods theories to private-sector public goods in the organizational alliance field have been quite limited and have focused on the *distribution* or maintenance of goods rather than their creation. For example, attention has been drawn to the distribution of substantial benefits to member firms in Japanese *keiretsu* and Korean *chaebol* forms of alliance and the resultant effects on global economic activity. However, these processes have not been formally modeled using public goods theory, and their initial production processes have drawn little more than historical interest. Recently, however, an attempt has been made to describe the distribution problems associated with alliance-based interorganizational information systems benefits. Kumar and van Dissel (1996) identify several key issues in maintenance of information bases, including dumping poor quality information in the pool, infecting the system with viruses, diverting jointly owned information resources for a participant's individual use, and taking advantage of partners by stealing private information from the shared system.

Information and communication public goods can be

produced from at least four types of alliances. *Precompetitive* alliances (Yoshino and Rangan 1995) are designed to produce the conditions necessary for effective competition. Examples include research networks for co-operation in R&D among firms that later will employ the results to compete in product markets (e.g., ESPRIT, SEMATECH). A mixed public/private sector example is alliances created through Cooperative Research and Development Agreements (CRADAs) which enable federal laboratories and private sector firms to transfer government technology for private sector product development. Precompetitive alliances also may attempt to build a common communication infrastructure for global competition through standards-setting and construction of the physical networks for worldwide information transfer. Examples are international standards-setting organizations for global information transmission protocols.

Joint value creation alliances allow partners to compete as a team in product markets or to jointly provide better service (Balakrishnan and Koza 1993, 1995). Examples in the private sector include the multitude of alliances to develop and ultimately market integrated broadband communication services (Fulk and DeSanctis 1998). These alliances include such diverse partners as cable operators, regional telephone companies, Internet service providers, hardware manufacturers, software producers, long distance telecommunications providers, television and motion picture studios, and satellite service providers (Baldwin et al. 1996). An example in the public sector is multijurisdictional alliances among law enforcement organizations, drug treatment centers, and community groups to share information related to control of substance abuse (e.g., Chaiken et al. 1990).

In *competitive* alliances a public good is produced and distributed among firms that simultaneously compete in product markets. An example is the benefits offered by the claims database maintained by firms that market automobile insurance. This database allows firms to obtain information from their competitors about claims histories for individual applicants or insureds. Each firm has agreed to share claims information with the understanding that all firms in the industry can better manage risk when they have full information on individual drivers.

Finally, *value chain* alliances based on information public goods reduce transaction costs between buyers and suppliers. This typically occurs because each participant invests in efficiency-producing information and communication systems that reduce coordination costs (Malone et al. 1987). An example is the electronic data interchange (EDI) network that links General Motors and its multitude of suppliers.

Yet, not all alliances offer the potential to create public

goods. Alliances that promote individual learning but attempt neither to create value jointly nor develop broadly connected communication networks are not oriented toward public goods. For example, alliances by partners in two different industries may be explicitly targeted at acquiring information about the other industry without any significant intent to create new value or produce other shared, mutual benefit; separate private benefits are what drive the alliance. The goods created in this instance are private goods to each partner rather than shared public goods. (Khanna (1998) provides an interesting exploration of the interrelation of private and common, i.e., collective, benefits.)

This article offers a model for research on the production of alliance-based interorganizational communication and information public goods. The formulation draws on earlier extensions of public goods theory to interactive communication systems in general (Fulk et al. 1996). The model is focused on multifirm alliances rather than dyadic partnerships, which have been explored extensively using game theoretic concepts. (See, for example, Ariño and de la Torre (1998) and Larsson et al. (1998).) Finally, it is worth noting for clarity that multifirm alliances are frequently described with a variety of terms such as networks (Sydow and Windeler 1998) and constellations (Jones et al. 1998).

The article begins with a brief overview of the basic principles of public goods theory, drawing in particular upon the integrative theory proposed by Marwell and Oliver (1993). This framework is applied to alliance-based interorganizational communication and information (ICI) systems, highlighting two key public goods that such systems can generate: connectivity and communality (Fulk et al. 1996). The subsequent section develops 23 propositions on alliance-based ICI systems as public goods. The presentation concludes with an application of the propositions for an alliance among law enforcement organizations.

Public Goods Theory

Marwell and Oliver (1993) integrated a diverse set of research findings on public goods to propose a theory describing four key factors affecting collective action. The first factor is characteristics of the *good*. Public goods vary on a number of dimensions. For example, some goods are continuously divisible and can be produced through an accumulation of parts, such as a compendium of reports, while others are not valuable unless they are produced as a whole, as in SEMATECH's industry infrastructure. Also, goods may be heterogeneous, in that they

may have several dimensions that are differentially valuable to different individuals, much like a political platform (Hardin 1982). The second factor is the characteristics of the *participants* who comprise the group. In the case of alliances, participants could include actual and potential partner organizations as well as the individual persons representing these organizations. Participant characteristics include the interests that they have in attaining the public good, the resources they can contribute to achieving it, the costs related to contributing, and the gain they accrue from its provision. The third factor is the collective *group* of participants. Key characteristics are group size and heterogeneity. Heterogeneity refers to variation in interests and resources across the participants in the group, such as wealth or expertise. The fourth factor is the characteristics of the *action processes* that produce (or fail to produce) the good, particularly the degree of interdependence that occurs among participants. One form of interdependence is the degree and type of information that participants possess about each other's decisions regarding contribution to the collective good. Another form is the character of the social network that links participants. Further, interdependence is often fostered by organizers who attempt to mobilize action by communicating to others.

Marwell and Oliver's (1993) theory is formalized in a production function and a set of auxiliary mathematical equations. The following *gain equation* provides a general expression of the production function:¹

$$g_i(R, r) = v_i[P(R)] - c_i(r).$$

This equation relates the net gain members of the collective derive from a collective good to the benefits and costs associated with providing the good. The gain, g_i , for the i th participant is equal to the good's value, $v_i[P(R)]$, minus its cost, $c_i(r)$. Unpacking the value term, the function $P(R)$ relates the provision level of the good, P , to the total resources contributed, R . This is the production function. The value experienced at any given level of the good by the i th participant is $v_i(P)$. Meanwhile, the i th participant who contributes r resource units experiences a subjective cost, $c_i(r)$. Cost equals zero for participants who contribute nothing. The total resources contributed, R , is defined to be equal to the sum of participant contributions (r) (Marwell and Oliver 1993, p. 25).

Three functional relations on the right-hand side of the equation describe a chain of events that lead toward the provision of a collective good. They include the costs participants bear when they contribute resources, $c_i(r)$, the collective good produced from resource contributions, $P(R)$, and the value participants derive from the provision of the good, $v_i(P)$. The first relation, $c_i(r)$, consists only

of participant-level variables (denoted by lower case letters) and is a subjective outcome distinctive to the i th participant. The second relation, $P(R)$, consists only of collective-level variables (denoted by upper case letters). Of the three relations, it is the only one that is wholly independent of participant preferences, describing an objective property of the production process (Marwell and Oliver 1993, pp. 25–26). The third relation, $v_i(P)$, is another subjective outcome, but it spans collective-level production and participant-level realization of the good's value. Figure 1 illustrates the entire production function, including gain. It illustrates how the variables fall within the three levels of the equation by grouping them respectively into an ellipse to represent the participant level, a rectangle for the collective level, and a triangle to bridge the two.

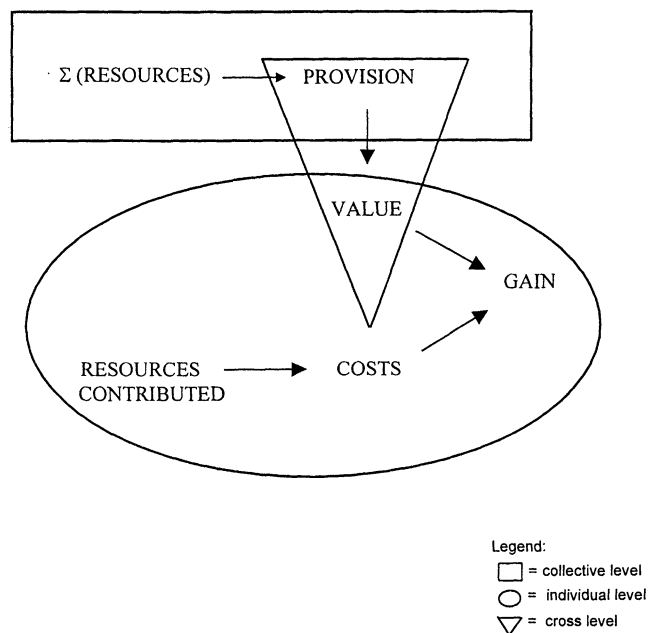
The model of alliances based on ICI systems that produce public goods is organized around Marwell and Oliver's (1993) four-part framework comprised of the good, the participants, the group, and the action processes. Initially, the good is discussed in terms of the concepts of connectivity and communality, a distinction that is built upon throughout the article. Subsequently, propositions pertaining to ICI systems are developed for each of the four parts of the framework.

ICI Systems for Producing Public Goods in Alliances

1. Characteristics of Connective and Communal Collective Goods

ICI systems offer two classes of public goods labeled connectivity and communality (Fulk et al. 1996). Note that the ICI system itself is not the good; rather, the good is the functionality that the ICI system affords for the participants in the alliance. Connectivity and communality are general classes that describe a variety of different subgoods. One connective good described later is universal access across alliance partners; one communal good, also described later, arises from jointly held discretionary databases.

Connectivity. Connectivity as a public good is the ability to reach other members of the interorganizational collective (e.g., participants in the alliance) through the ICI system. A system is fully connective if each member can reach each other member through direct communication. The rationale for creating a fully connective good is that the whole alliance benefits from the ability of all members to communicate directly with each other. For example, consider an alliance to develop integrated broadband services. The cable operator benefits not only

Figure 1 Graphic Representation of the Gain Equation with the Production Function

from its ability to communicate directly with software and hardware producers, but also from the ability of software and hardware producers to communicate and coordinate directly with each other. A potentially less costly alternative to full connectivity is optimal connectivity, where many but not necessarily all members are directly connected. Some links may be excluded due to cost of connection or to infrequent need for direct communication. Full connectivity is generally desirable when the needs for direct connection between specific participants are unpredictable. Optimally connected systems may be cost effective where communication contacts are relatively predictable, unchanging, and differ substantially in relative cost or value.

Connectivity has two components: physical and social. *Physical* connectivity among the nodes is achieved by the infrastructure that supports direct communication. This includes the local or wide area networks, the Internet, intranets, and other hardware and software that make direct linkage technically possible. *Social* connectivity is the actual use of the physical connections by members of the alliance. Social connectivity fails, for example, when people do not read their electronic mail. Physical connectivity is a necessary but not sufficient condition for social connectivity.

Social connectivity differs from physical connectivity in another key characteristic: no set of participants can provide the benefit for all. Whereas a few participants

could provide the physical infrastructure for all, social connectivity is only achieved by the active participation of each member in the use of the physical infrastructure. Furthermore, social connectivity is not a good that can be obtained by free-riding. People who fail to contribute by using the ICI system also fail to benefit, since they are no longer socially connected.

Social connectivity highlights an interdependence among contributors that distinguishes it from some other public goods: participants must *continue* to contribute in order for the good to continue to exist. Since contributors can easily return to noncontributor status, the critical mass needed to achieve the good for the remaining members can be imperiled as defections snowball (Markus 1990, Rolphs 1974). Consider, for example, an alliance that maintains a secured website through which participants can post messages selectively addressed to one another. If even a fraction of the participants stops logging onto the site to collect or post messages, the site becomes less useful as a broad-based communication tool and still more participants are likely to stop using it once usage falls below a critical mass of connected participants.

Communality. Communality as a public good derives from collectively storing and sharing information, such as through an electronic bulletin board or an expert database to which users have full, unrestricted access. Communality is created when participants exchange information through shared databases. Systems that provide opportunities for communality can function as information marketplaces, helping different participants to communicate with each other through the information they contribute to a common pool. Information sharing of this type can also produce more than piecemeal exchange of information. Information may be assembled, reorganized, and analyzed to create new and additional information that is more valuable than its parts. For example, different organizations that have access to various types of information about international competition could pool that information to discover trends that would not have been visible from any subset of that information. Or, police organizations in different jurisdictions could pool their information gained from different informants into a joint database in order to piece together clues to a larger pattern of criminal activity.

When information resources are *distributed* so that different members of the interorganizational collective are able to make qualitatively different contributions, wide participation is essential to realize communality. Consider, for example, the database maintained by the automobile insurance industry on the claims history of drivers. Each insurer has relatively unique information about claims it has received. If even a subset of insurers fail to

contribute information, the comprehensiveness and thus usefulness of the database are imperiled. As a result, the database is less attractive to potential contributors, and the communal good may not be viable. Interdependence among contributors is also critical for continuing maintenance of a communal good when information resources are distributed. If some insurers do not regularly contribute updated information, even an initially successful database may fail as it becomes less valuable and additional insurers respond by withdrawing their regular contributions.

When information is *clustered* such that a subset of participants can control production of information, participation is only required of those who control it. A communal good might be created by such a subset of participants. For example, leaders in a domestic industry might collect information about the actions of global competitors and distribute it in an attempt to induce others in the domestic industry to behave in ways that protect them collectively from foreign competition. Or, in an alliance that includes participants from several industries, a single industry might share its own industry analyses with partners from other industries to create a shared database of competitive intelligence.

Universal Access and Discretionary Databases. Drawing on early work by economists (Rolph 1974), premises of collective action theory have been applied recently to communication and information systems in separate theoretical treatments by Markus (1987, 1990) and by Connolly (Connolly and Thorn 1990, Markus and Connolly 1990, Thorn and Connolly 1987). In the present application to ICI systems, a critical theoretical issue is how potential system users in an alliance can be induced to participate in the larger action to provide connective or communal goods. The *connective* public good in Markus' theory is *universal access*; that is, each member of the collective can communicate with each other member via the interactive medium. Because communication involves direct participation by members of an alliance, contributors are interdependent. The implementation will fail if there is not a sizable enough number of communication partners available through it. The potential for contributors to discontinue participation makes this problem doubly difficult as participants reassess their commitments to alliances (Ring and Van de Ven 1994, Smith et al. 1995, Zajac and Olsen 1993). A key to developing universal access is to achieve a critical mass of participants willing to contribute on a continuing basis before universal access has yet been achieved. Because there is less incentive to contribute in the absence of universal access, this good is difficult to establish without supplemental incentives.

Thorn and Connolly (1987) (Connolly and Thorn 1990) focus on a system that can produce a *communal* public good. Certain information systems represent what Connolly and Thorn (1990, p. 221) call a *discretionary database*, because they contain "a shared pool of data to which several participants . . . may, if they choose, separately contribute information." The key problem is that most participants in an alliance would prefer to avoid the cost of contributing information while benefiting from the information others contribute. This "free rider" problem implies that without countervailing incentives such databases will not be developed as long as potential contributors act in terms of their separate self-interests. The practice of sharing information communally is a collective action enabled in part by a discretionary database and fulfilled by participants' contributions of information. However, the public good is the functionality it provides members of an alliance and the information sharing that comes from its use rather than the database system itself.

Production Functions and Critical Mass. Production functions describe the level of public good produced through collective action as a function of resources contributed by members of an alliance. At any given point on the production function, $P(R)$, the difference between the value of the good produced and its cost indicates the total *gains* available to members of the collective, while the slope (dP/dR) indicates the marginal rate of return to contributors collectively. The function is said to be accelerating or decelerating where the slope is increasing or decreasing, that is, where the second derivative (d^2P^2/dR^2) is positive or negative, respectively.

Differences in production functions are associated with different social dynamics and with different likelihoods of actually producing the collective good (Marwell and Oliver 1993, Oliver et al. 1985). *Decelerating* functions describe situations in which the earliest contributors who help to establish the collective good have the greatest effect on its level, and subsequent contributions have progressively less effect. For example, those firms that initiate an R&D alliance by conceptualizing the partnership, communicating its feasibility within the industry, and contributing initial resources have the greatest likelihood of ensuring its success. In SEMATECH, Intel Corporation took this lead role (Browning et al. 1995). Subsequent contributions of expertise and resources increase the likelihood of success, but the incremental effect is smaller. When production functions are decelerating considerable incentives exist to initiate collective action because the first to contribute see the greatest benefits in terms of increasing the level of collective good. Ironically, however, the collective good is rarely *fully*

achieved due to the decreasing marginal rates of return seen by later contributors.

Accelerating production functions describe situations in which successive contributions to an alliance-based ICI system yield progressively greater rewards. When the production function is accelerating it is difficult to initiate collective action because the benefits to early contributors remain largely contingent on the subsequent contributions of others. For example, the first companies that support their supply chain alliance by using compatible electronic data interchange (EDI) systems benefit only from direct linkage with each other. As other companies use EDI links compatible to these earlier ones, more companies can communicate more widely. Each new link expands the possibilities for electronic information exchange geometrically and thus magnifies the benefits. Thus, if the initial contributions can be obtained, they will tend to snowball, and the collective good is likely to be achieved *fully* and thereafter sustained due to increasing marginal rates of return.

The payoff implied by the form of the production function is particularly important for alliance-based ICI goods because adopters can elect to return to nonadopter status simply by withholding additional contributions. Both social connectivity and communality depend upon sustained contributions so that the level of the good at any given time will depend upon the average *rate* of collective resources contributed. If the production function is accelerating, a failure to sustain even the last few increments in the rate of contributions will substantially diminish both the immediate value of the good and the likelihood of its continued provision.

Markus' (1990) argument leads to the hypothesis that the production function for connective goods will be accelerating because the greatest increases in connective benefit will be obtained at points approaching where all participants contribute. (It is assumed that after costs are paid to establish a basic connective infrastructure the marginal costs of adding more network linkages will be constant if not decreasing in magnitude.) In the case of communal goods, too, contributions that update and upgrade a database in the provision of communality should cause the production function to accelerate. Acceleration will tend to be greater in cases where information in the database is combined to create new information products more valuable than the sum of their parts. Acceleration will be less, and may approach zero, where the value of the communal good is a simple sum of the contributed information. This prediction assumes that contributions are unique. That is, the predicted acceleration in the production function for both connective and communal

goods is limited to domains where additional contributions do not consist of redundant network linkages or redundant information. Proposition 1 summarizes these arguments.

PROPOSITION 1. *Production functions for connective and communal goods in alliance-based ICI systems will be accelerating.*

Possible exceptions arise for connective goods, if some of the network links are substantially more important than others, and for communality in the case of clustered resources. The problem in these cases is the nonsubstitutability of contributions. In order to understand why this is a problem, it should be noted that the general form of Marwell and Oliver's (1993) production function combines participant contributions into the sum, R . Therefore, it cannot discriminate between contributions except on the basis of their magnitude, and it assumes that one contribution of a given magnitude, r , can be substituted for any other. However, if the relative importance of contributions varies significantly in ways that their relative size does not capture, then the production function must be modified to deal with such cases. For example, in place of Marwell and Oliver's term $P(R + r)$ to express the level of the good when a contribution of r units is added to the most recent level of R (Marwell and Oliver 1993, p. 35), the term $P(R + r_i w_i)$ could be used instead, where r_i denotes a contribution by the i th participant and w_i is a relative weight associated with that contribution (see Sandler 1992, p. 36). This modification does not in itself alter the predicted tendency toward acceleration. So long as the weights are all positive constant values, the signs of the first and second derivatives will not be affected and contributors may see different marginal rates of return but will all see acceleration or deceleration at the same points along the curve.

For Proposition 1 to hold even in the presence of non-substitutable contributions, however, the key condition is that the relative magnitudes of the weights not differ so greatly that the production function's shape becomes dominated by the sequence of more and less heavily weighted contributions over time. This condition is more likely to be satisfied for ICI systems in which the frequency of users' repeated contributions is greater, since this should cause contributions with different weights to be interleaved over time. The effect would be simply to add a degree of jitter around the average (accelerating) trace of the production function's curve. On the other hand, there are two situations in which Proposition 1 can be expected to fail. First, variation across weights can be so great as to create swings in the curve too wild to permit estimation of the second derivative, making the predic-

tion untestable. Second, contributors who are most heavily weighted might change their rates of contribution only at lower levels of the provided good (e.g., an initial group of key contributors), while contributions at higher levels of the good might come from contributors who are less heavily weighted, thus providing only diminishing returns. In the latter situation, sufficiently large variation in the weights across contributors will cause the production function to be decelerating because the effect of the most heavily weighted contributions is greatest at lower levels of the provided good, making the slope of the curve steepest in that range.

Connectivity, Communal, and Outcomes of Collective Work. Considerable research has been conducted on the role of collaboration tools on outcomes such as performance, satisfaction, and consensus, as well as decision task outcomes such as quality, confidence, and satisfaction (Fulk and Collins-Jarvis 1998, Jessup and Valacich 1993). Although research on system support is still relatively young, it has been widely demonstrated that interactions supported by collaborative technologies enjoy significant advantages and facilitate positive collective outcomes (Benbasat and Lim 1993, Dennis and Gallupe 1993). Although much of this research has been on non-distributed systems, a small number of studies have focused on interorganizational, distributed collaborative systems (Fulk and Collins-Jarvis 1998, Kumar and van Dissel 1996).

For example, the *quality of information and decisions* has been found to improve with the aid of system support (Easton et al. 1990, Jarvenpaa et al. 1988, Sharda et al. 1988, Steeb and Johnston 1981, Valacich et al. 1993). Higher quality information and decisions are seen to result from the enhanced communication, information, and decision support capabilities of collaborative technologies, which offer opportunities for more equal participation, ease of communication and idea sharing, and facilitation of interaction via technological intervention. The effect of technological support on decision quality (a) is consistent across high and low difficulty tasks (Gallupe et al. 1988), (b) is more pronounced in larger collectives (Gallupe et al. 1992, Valacich et al. 1991), and (c) can lead to decisions that are more extreme or risky (Sproull and Kiesler 1991).

Collaborative system support has also been shown to increase the *amount of information available* and the *number of alternatives produced* in generative tasks. Communication and decision support technologies have been found to help participants produce more unique alternatives (Gallupe et al. 1991, Gallupe et al. 1992, Valacich et al. 1993), particularly in larger collectives (Valacich et al. 1991). Researchers propose that mediated

communication increases the number of ideas generated by reducing social barriers, thus facilitating consultation of a wider base of the collective's members (Bikson et al. 1991, Sproull and Kiesler 1991). In this way, input by members of the alliance is increased and leadership roles become more distributed, resulting in more information shared by, and available to, the entire collective.

The effects of system support on participant *satisfaction with process and outcome* are somewhat equivocal, yet still clearly relevant to the provision of communication and information public goods through collaborative technologies. Research on support systems has found positive (Dennis and Gallupe 1993, Eveland and Bikson 1989, Steeb and Johnston 1981), negative (Benbasat and Lim 1993, Gallupe et al. 1988, Gallupe and McKeen 1990), and mixed or no support (Easton et al. 1990) for the relation between collaborative technologies and user satisfaction with process and outcome. Kraemer and Pinsonneault (1990) found communication support systems to decrease user satisfaction while decision support technologies increased satisfaction with processes and decisions. However, recent reviews and studies are beginning to organize these discrepant findings by examining the effects of moderating variables such as group size and type of task. In their meta-analysis of experimental studies on collaborative support technologies Benbasat and Lim (1993) found that while support systems had negative main effects on user satisfaction, larger collectives were more satisfied with the use of support systems. This moderating effect was proposed to be a function of the attendant problems associated with larger groups (e.g., reduced time for the expression of opinions, unequal participation, and general process losses) that might be addressed by technological system support. Similarly, the application of more sophisticated support tools resulted in greater satisfaction than simpler conferencing tools. Hollingshead et al. (1993) found that lower satisfaction effects for conferencing support disappeared over time and with experience in using the tools.

Based on these research findings, the following benefits can be expected to result from the development of alliance-based communication and information public goods: (a) *high quality of information available*, (b) *substantial amount of information generated*, and (c) *member satisfaction with group process*. If a connective or communal good is realized in large part (i.e., at least a critical mass obtains), then a proportional share of these benefits of a truly collaborative environment should accrue to participants. Traditional public goods theory predicts the likelihood of realizing the good. With respect to the public goods of connectivity and communal, however, research evidence on the effects of information and communication technologies makes it possible to extend

predictions another step to these collective organizational outcomes.

Interorganizational outcomes are relatively unexplored in existing formulations of information-related public goods theories and studies of computer-supported collaborative work. This is due to a number of challenges in conceptualizing and studying such collectives. First, participants lack shared organizational visions, goals, structures, reward systems, cultures, and other unifying mechanisms that facilitate contribution to interorganizational systems. Second, individual persons function both as individual users and as representatives of their organizations. Research must take into account not only individual contributors but also how individual efforts cumulate to create organizational contributions which, in turn, are cumulated into an interorganizational system. Third, organizations that use the ICI system are likely to be required to share the benefits with alliance partners, some of whom may also be competitors. The success of a cooperative orientation depends on the willingness of each participant to forego self-interest and short-run gains by sharing information that may lead to greater collective gains over the long run, thus forestalling opportunism (Hamel 1991, Kumar and Nti 1998). Propositions 2 and 3 predict that the total resources contributed toward provision of the good will impact organizational effectiveness.

PROPOSITION 2_(a-c). *Over time, increases in the provision of connectivity through an alliance-based ICI system will be associated with increases in organizational effectiveness in the form of overall (a) quality of information available, (b) amount of information generated, and (c) member satisfaction with process.*

PROPOSITION 3_(a-c). *Over time, increases in the provision of communality through an alliance-based ICI system will be associated with increases in organizational effectiveness in the form of overall (a) quality of information available, (b) amount of information generated, and (c) member satisfaction with process.*

2. Characteristics of Participants

Marwell and Oliver's (1993) production function equation proposes that gains from collective action depend not only on level of the collective good itself, but also on participants' interests, costs, and resources contributed, or in Madhok and Tallman's (1998) terms, "the net value of the collaborative transaction." (p. 328; The terms value and interest are both used in the literature to refer to what Marwell and Oliver (1993) describe as the value component of the production function.) Participant gains are specifically (1) a positive function of participant interests which are, in turn, a function of the good's provision, and

(2) a negative function of participant costs, which themselves are a function of resources contributed.

Interests. Interests are among the most important aspects of public goods. The likelihood of contributing is related to the level of interest in seeing the good realized. Interests vary over time in relation to several factors. First, application of the production function equation to alliance-based ICI goods suggests that as system adoption increases among the partners and increased communality or connectivity obtains, interests can be sparked by perceptions that its ultimate level will be higher than first appeared likely. Second, interests are subjective (Klandermans 1984) and will change over time as understandings change (Marwell and Oliver 1993). Third, connective and communal benefits that derive from new and complex ICI systems often are not clear to potential contributors in the early stages. Interests may grow as initial system features are refined, initial outcomes appear, and the benefits of system use are publicized. For example, Browning et al. (1995) describe how interests in SEMATECH grew over time as leaders made substantial contributions, expressed expectations that others would contribute at least a minimal amount, and people increasingly understood the feasibility of the collective effort.

Fourth, interests may vary over time in relation to the availability of alternative media systems. For physical connectivity, for example, the availability of a fully connected telephone network in developed countries that carries a high quality signal has helped to facilitate interorganizational connectivity through fax, electronic mail, electronic data interchange, and the Internet. By contrast, the lack of a reliable and fully connected telephone network in a number of underdeveloped countries has impeded the development of such connectivity. To date, comparatively few Internet nodes exist on the whole African continent. And, the lack of an adequate civilian terrestrial telecommunication infrastructure in countries such as Russia and China has led a number of global businesses to attempt development of international satellite telecommunication systems to overcome the problem (e.g., the Iridium project). For social connectivity, interests in a new medium are intricately related to the connectivity provided already through existing media and users' interests in retaining these media. Substitutability across media is likely to work against attaining full connectivity for a new medium. Interests in connectivity through new media can be dampened in the presence of acceptable alternatives to the point that a new medium fails. For example, use of a new secured website for message exchange between alliance partners may never attain critical mass if partners can already exchange email through their regular email systems. However, in some

situations the availability of alternatives might have the opposite effect and improve connectivity. For example, new computer office suite software supports easy distribution of the same message by both email and fax modem. Through a combination of the media, the total system could be fully connected.

Fifth, the pace of technological change in ICI systems is such that interests in a system may wax and wane over time as new features are refined and improved, old features are discarded, and new functionalities are incorporated into the systems. An example is the increasing availability of Internet-based video conferencing tools that offer a common platform for physical connectivity. In this sense, ICI systems differ substantially from traditional public goods whose basic configurations are expected to be relatively stable over time. Thus, examination of ICI systems requires incorporation of a concept of changing interests over time in relation to changes in functionalities afforded.

PROPOSITION 4. *Over time, increases in participant interests in an alliance-based ICI system will be positively related to increases in participant gains.*

Costs. Costs for connectivity and communality include costs for both physical and social contributions. Costs for the physical system typically include hardware, software, and the application of political or other resources to induce expenditure of the necessary financial resources. These costs can be covered in several ways. One way is for a subset of alliance partners to contribute the physical system for use by all partners. An alternative is for a subset to provide the central “backbone” infrastructure while requiring individual users or firms to provide local access devices. Alternatively, users or firms can be required to cover the costs of both local access and the backbone system. The latter two cases involve some degree of direct costs to all members of the collective for the physical system, and thus require a broader base of acceptance and participation in order for the physical system to be viable.

Social connectivity and information contributions require a different set of costs, including both subjective and objective factors (Marwell and Oliver 1993). They include such things as learning how to use the new system, making useful contributions to the database, compiling information, giving up established ways of doing things, developing new ways of working, and developing and maintaining the interactive social networks required to use the system (Connolly and Thorn 1990). Markus (1990) also describes the need for “communication discipline”—making oneself available by receiving and sending communications. Each participant incurs the

costs listed above in relation to the amount of resources contributed. An examination of these costs reveals that many of them must be borne by those seeking to *acquire* information from a communal database, even if they do *not* contribute information of their own (i.e., even if they “free ride” on contributed information).

An important issue in the development of public goods over time is the existence of both start-up (nonrecurring) and recurring costs. Start-up costs involve the expenditure by participants of resources required for initial system use that will diminish to zero over time, such as the development of new methods and procedures of operation and the related phenomenon of giving up cherished ways of doing things. Recurring costs for participants involve the expenditure of resources required to use the system, such as time and effort, which continue indefinitely over time. These can be particularly problematic if participants are free to return to nonparticipant status at any time, where even universal access can be threatened after it is realized.

PROPOSITION 5. *Over time, decreases in the participant start-up costs associated with using a new alliance-based ICI system will lead to increases in participant gains.*

PROPOSITION 6. *Over time, decreases in the participant recurring costs associated with using a new alliance-based ICI system will lead to increases in participant gains.*

Resources. Participants choose how much of their information resources they will contribute to an alliance-based public good. Key information resources include data, knowledge, and human intelligence. Information contributions may be voluntary or, as hypothesized later in the section on action processes, may be induced through the efforts of organizers. Whatever the reason for contributing information, continuing success of the system depends on continued contributions from participants. Success, however, does not depend solely on amount of information contributed. Quality dimensions of contributed information such as timeliness, accuracy, and relevance also play an important role. Resources related to social connectivity stem also from participants’ efforts to be accessible through the system.

For alliance-based ICI systems, several other factors have been found to be critical to participant decisions regarding resource contributions. Information security is a key factor because participants are unlikely to contribute unless they are confident that the system is secure. This is especially true when the information is of great value to competitors, the organization has fiduciary responsibilities to protect sensitive financial or personal

data, and in military organizations heavily invested in secrecy or confidentiality (Bok 1989). *External confidence* is the perception that the system is secure from outside tapping. *Trust* is the expectation that alliance partners will not themselves compromise sensitive information, recognizing and protecting the rights and interests of contributors when sharing and exchanging information. As Hosmer (1995) emphasized, individuals place trust not in a system, as is the case with external confidence, but rather in other individuals. Participants must have confidence in both others' competence in using that information and in others' intentions in using it. The role of trust in interpersonal communication has a long and distinguished research history. Recently, considerable attention has been drawn to the role of trust for effective interaction in interorganizational communication and alliances (Granovetter 1985, Cummings and Bromiley 1996, Powell 1996). Levels of trust and external confidence are likely to vary significantly across participants, as well as within participants over time as they develop experience with the system and with specific communication partners.

PROPOSITION 7. *Over time, increases in external confidence will lead to increases in individual resources contributed.*

PROPOSITION 8. *Over time, increases in trust will lead to increases in individual resources contributed.*

As indicated in our discussion of the production function, the contributions of different participants to an ICI system are not necessarily equal in importance or value. This inequality can impact resource contributions. Any given participant's *key collaborators* can be defined as the partners with information resources that are most critical to that participant. If a participant's key collaborators contribute to a connective and/or communal good, that participant is more likely to participate in the provision of the good. At the collective level, if enough key collaborative relationships eventually join in the effort, a point of critical mass is reached and use of the system should be self-reinforcing from that point forward (Markus and Connolly 1990). This point of critical mass is most likely to be reached in situations where a small number of participating community members hold critical information resources relevant to large segments of the community.

PROPOSITION 9. *Over time, increases in the anticipated and/or actual use of the system by a participant's key collaborators will lead to increases in participant resources contributed.*

3. Characteristics of the Group

Heterogeneity. Oliver, Marwell, and Teixeira (1985) argue that heterogeneity of interests (ability to benefit) and resources (ability to contribute) across participants affects collective action. Those participants with the greatest interest in the shared good will contribute the most, while those with the least interest are most likely to free ride on others' contributions. Similarly, those with the least resources are least likely to contribute to collective action. This is the pattern reported for SEMATECH (Browning et al. 1995). Oliver et al. (1985) note the implications of these factors:

If an interest group is heterogeneous, there may be some highly interested or highly resourceful people available for a critical mass even when the mean interest or resource level is rather low. . . . Interest heterogeneity is always significant, whereas resource heterogeneity is much more important when the production function is accelerating. . . . A positive correlation between interest and resources is highly favorable for collective action, as it increases the probability of there being a few highly interested and highly resourceful people who are willing and able to provide the good for everyone (pp. 529–530).

Oliver (1993) points out that heterogeneity facilitates collective action when the mean level of resources in the collective is not sufficient. However, when the mean level is sufficient, heterogeneity can inhibit collective action under conditions of a fixed, limited opportunity to contribute. For example, consider the situation in which a legal or other restriction exists on the amount that a single organization can contribute to an alliance for political action. Failure is most likely when the group is so heterogeneous that those with the fewest resources can contribute little, while those with the most resources are prohibited from contributing enough to make up the difference. Mean level of resources is generally more important than resource heterogeneity, whereas interest heterogeneity is generally more important than mean level of interests (Marwell and Oliver 1993, p. 20).

This issue is similar to that of distributed versus clustered resources in producing a communal good. When information is distributed such that each participant uniquely possesses important information, no subset of a few participants can contribute enough to create the good for the benefit of all. Creation of the good requires broad participation. But Connolly and Thorn (1990) argue that in such a situation the payoff function, that is, the structure of individual gains, makes it difficult to energize sufficient action to create the good. Each participant that contributes information receives no direct benefit, since

the contributor already knows the information, but would have to pay whatever costs are involved in making the contribution. Thus, there is a disincentive toward contribution. Like all instances of free-riding, this situation is analogous to the N-person Prisoner's Dilemma in which all parties stand to gain if everyone contributes, but each participant can seek to be still better off by free-riding on the contributions of others. Alternatively, when information resources are clustered, those who control the bulk of it might mobilize themselves more readily to create the good for the whole collective.

Heterogeneity of interests is also affected by the relative specialization or differentiation among participants (Markus 1990). In cases where all participants hold unique or important information other participants need, all participants have a high need to acquire information from others and the mean level of interest is high; interest heterogeneity is low. Resources, however, are distributed; thus, creation of the good requires broad participation. Under such circumstances participants have high perceived task interdependence, or the belief that they belong to an existing or latent collective whose members rely upon each other's actions. An example of this situation is how the RISC constellation of Hewlett Packard was designed to function on the basis of economic specialization across participants. Alternatively, when specialization causes some participants to be asymmetrically dependent on others, then the mean level of interests is lower, and interests in providing the good are heterogeneous. For example, consider an alliance among various architectural, engineering, and construction software developers and a firm that provides data on typical building types for use with the software. The latter firm is asymmetrically dependent in that its data are useless without the software platform. Interests in creating a joint database and communication system that will support their joint development effort are likely to be greater in this firm, which therefore may be more willing to mobilize efforts to create the good.

Similarly, *geographic dispersion* of information sources implies that distant sources will be more interested in interactive media than proximate ones as a means of communicating vital information. Such dispersion among participants leads to interest heterogeneity since participants are likely to have varying interests in the provision of the alliance-based connective or communal good based on their relative degree of isolation. Also, geographic dispersion creates task interdependence to the extent that distant sources can serve as "remote sensors" for each other (Markus 1990).

PROPOSITION 10. *Over time, across participants in ICI systems, greater interest heterogeneity will be asso-*

ciated with increases in the amount of resources contributed toward connectivity and communality within an ICI system.

PROPOSITION 11. *Over time, across participants in ICI systems, when controlling for limits imposed on contributions, greater resource heterogeneity will be associated with increases in the amount of resources contributed toward connectivity and communality within an ICI system.*

PROPOSITION 12. *Over time, higher correlations between resources and interests where resources and interests are heterogeneous will be associated with increases in the amount of resources contributed toward connectivity and communality within an ICI system.*

PROPOSITION 13. *Changes in the relative levels of perceived task interdependence between members of different organizations will be associated with increases in interest heterogeneity, leading to greater resources contributed toward connectivity and communality within an ICI system.*

PROPOSITION 14. *Geographic dispersion of organizations will be associated with increases in interest heterogeneity, leading to greater resources contributed toward connectivity and communality within an ICI system.*

Size of the Public. What size collective is most likely to prevail in creating a public good? This issue has generated substantial debate in collective action circles. Olson (1965) argued that willingness to contribute was directly related to noticeability of contribution and ability to make a visible difference in the level of the good. He concluded that large collectives were less likely to succeed because contributions and their effects were less noticeable. Critics such as Oliver and Marwell (1988) argue that high jointness of supply makes costs unrelated to group size. Markus (1990) claims that size of the collective is related in complex ways to the realization of universal access. Large collectives are favored when substantial infrastructure is required or when benefits increase with number of users, since total benefits increase more rapidly than per-user costs. For example, a costly communication system that links only regional firms is less likely to succeed than one that links firms nationally; typically, the latter system enjoys greater economies of scale. But when little infrastructure is required, small collectives are more likely to realize universal access because costs are proportional to the number of users. The complexity of the size issue suggests that size masks a variety of other key variables that deserve

investigation in their own right. This reasoning leads to the following two propositions:

PROPOSITION 15. *Over time, increases in the noticeability and visible effect of contributions to an ICI system will be associated with increases in the amount of resources contributed toward connectivity and communality within an ICI system.*

PROPOSITION 16. *The greater the costs of information infrastructure for an ICI system, the more positive will be the relationship between size of the collective and the amount of resources contributed toward the level of connectivity and communality within an ICI system.*

Figure 2 presents an integrated model of this evolving set of relationships in the production function.

4. The Action Process

Social Networks and Collective Action. Premises articulated for information-based collective goods have largely assumed that contributions take place independently, without explicit coordination across potential contributors, but with awareness of the actions of others. Once the possibility of coordination and explicit communication among potential contributors is considered, as is the case in alliances, the likelihood of collective action increases (Marwell and Oliver 1993). The quality and character of that communication is integral to understanding how concerted decision making and coordinated action grow and develop. A key concern is how the form and extent of linkage affect collective decision and action (Sydow and Windeler 1998).

Marwell and Oliver (1993), Markus (1990), and Monge and Contractor (1998) describe factors relevant to communication and coordination among potential contributors that can be seen to impact collective action directly. *Network density* refers to the proportion of organizations in the network to which an organization is directly connected (Monge and Eisenberg 1987). High network density contributes to collective action by providing extensive linkages for sharing information and other resources. In the case of alliance-based ICI systems, existing dense communication networks that predate ICI system implementation can facilitate the development of new ICI-based connective and communal goods (Fulk and DeSanctis 1995, Monge and Fulk 1998). *Network centrality* is the sum of the length of the shortest paths by which an individual or organization typically "reaches" or connects to every other individual or organization (Monge and Eisenberg 1987). Centrality promotes collective action because centralized communities can coordinate collective action more easily than decentralized communities (Marwell and Oliver 1993). For example,

CRADA partnerships often include firms that have worked together as subcontractors and whose top executives know each other well both professionally and personally and thus have direct network ties.

PROPOSITION 17. *Over time, increases in the density of extant communication networks for each organization will lead to increases in the amount of resources contributed toward connectivity and communality within an ICI system.*

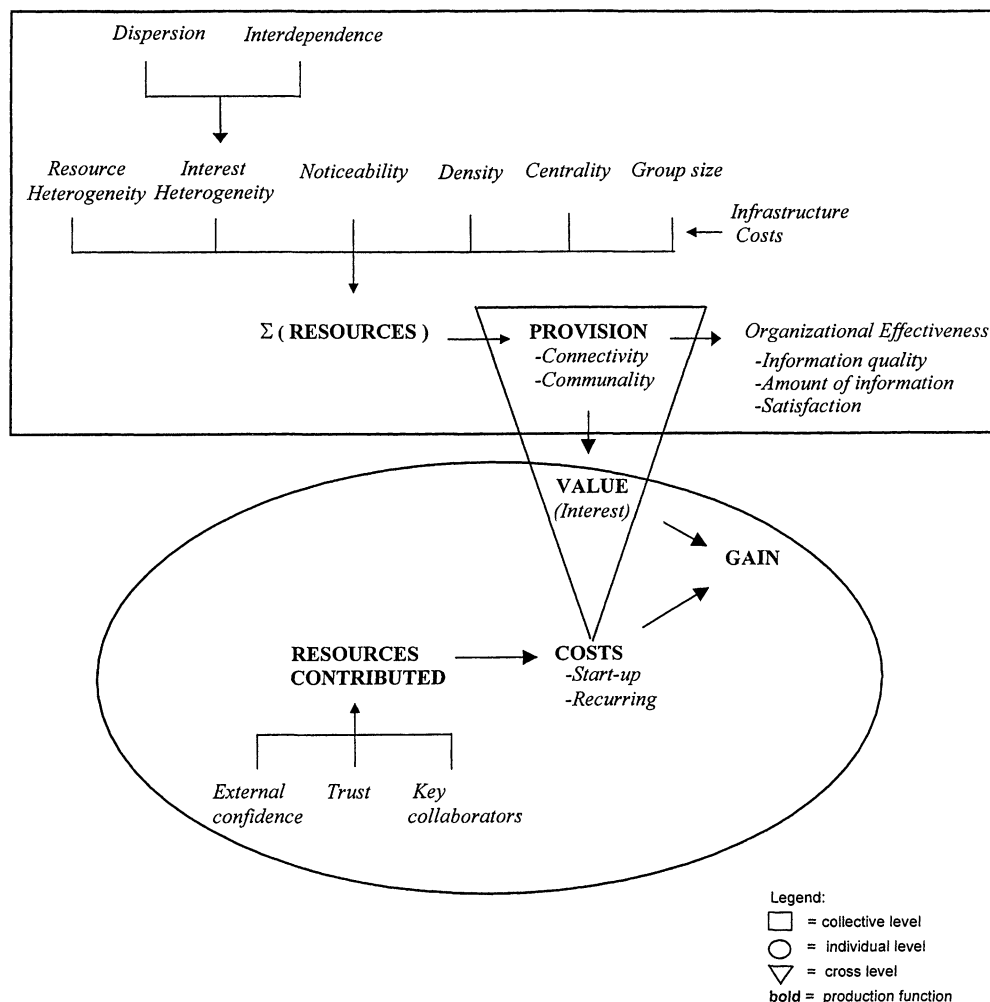
PROPOSITION 18. *Over time, increases in the centrality of communication networks for each organization will lead to increases in the amount of resources contributed toward connectivity and communality within an ICI system.*

Interplay of Connective and Communal Goods

The model described up to this point reflects a direct application and theoretical expansion of economic and sociological models of public goods to those goods that potentially can be provided by alliance-based ICI systems. In contemporary alliances, many ICI options are available for achieving communicative goals (Monge and Fulk 1998). The multiplicity of options raises the possibility of both tradeoffs and interactions among the different connective and communal capabilities available to alliance partners (Monge 1994). The section on participant factors described several possible effects of employment of more than one connective type of system, such as fax and email. In this section several possibilities are suggested regarding the interplay of connective with communal goods. The argument is that situations exist in which a communal good is more likely to develop than a connective one, and vice versa.

Trust and Participant Resource Contributions. Proposition 8 asserted that over time, increases in participant trust will lead to increases in participant resources contributed. The logic of this proposition rests on the trust felt toward partners to use information properly and refrain from opportunism (Williamson 1985). Such trust increases the likelihood that participants will voluntarily contribute accurate and timely information.

A key difference between communal and connective systems is that communal systems offer the advantage that the contributor need not know ahead of time which participants need or seek that contributor's information. Shared databases can serve as information marketplaces that link information contributors with recipients who may or may not be known to the contributor. The flip side of this advantage is that contributions to a truly communal database are available to all members of the collective, including those unknown to the contributor, whether the

Figure 2 Graphic Representation of the Integrated Model

contributor seeks such broad distribution or not. A counterincentive to contribution exists if a potential contributor does not trust some members of the collective to employ the information in ways acceptable to the contributor. In such cases, the contributor will more likely prefer to distribute information selectively to trusted recipients. At the limit of such selectivity are dyadic exchanges that constitute connective rather than communal goods. For example, in a CRADA studied by three of the authors, trust levels were highly asymmetrical. Participants elected to post little information of value to the secured communal website, preferring more targeted phone and email messages.

PROPOSITION 19. *The lower the individual trust in members of the collective, the greater the individual's resource contributions to a connective relative to a communal good.*

Relative Provision of Connective Versus Communal Public Goods. The unique advantages of the information marketplace provided by communal goods also may lose attraction when members of the collective know each other well and have established dyadic communication links. Posting information in a communal database may not offer advantages in small collectives where each member is able to make direct dyadic contact and perhaps thereby have greater assurance that messages are delivered to each intended recipient. Proposition 17 proposed that the density of extant networks facilitates information sharing through new ICI systems. Density, then, may favor connective over communal goods, especially where each community member can easily and economically be reached by direct connection.

PROPOSITION 20. *The greater the density of communication networks within a community, the greater the*

provision of a connective good relative to a communal good.

Interest and resource heterogeneity are hypothesized in Marwell and Oliver's (1993) theory to positively impact provision of a public good. Similar arguments were made for Propositions 10 and 11. Heterogeneity suggests that there may be some participants with adequate interests and resources to help create the good even in the absence of sufficient mean levels of interests and resources. At the same time, interest heterogeneity in particular suggests there may be some members of the collective with comparatively little interest in the good whose inclusion diminishes the good below its optimum level. In heterogeneous situations, the greatest *interests* may be confined to a portion of the community that may also have the most information *resources*. This high-interest, resource-rich subset of community members might elect to share information among themselves rather than provide a communal good for the broader benefit of all. One way to do this is through dyadic information sharing confined to that portion of the community where interests are high. This condition favors the provision of a connective rather than a communal good. An example is the relatively unsuccessful attempt to create an information clearinghouse to help community members recover from the 1992 Los Angeles riots. Some activists were highly interested in creating such a resource. However, there was a lack of both resources and understanding of possible benefits among the disaster-stricken low-income community members. In combination, these factors prevented creation of the clearinghouse, and citizens gathered information in less systematic ways that relied more on dyadic exchanges.

PROPOSITION 21. *To the extent that resources and interests are heterogeneous and there exists a portion of the public wherein the highest levels of resources and interests both are found, the provision of a connective good is more likely relative to the provision of a communal good.*

One factor that might mitigate a potential bias for the resource rich to share information only among themselves is the benefit that might be derived from sharing information with the resource poor. This might occur, for example, when a few cities that face the most narcotics crime, and have highly active anti-narcotics police units, create a narcotics crime database that is accessible to all cities in a region. Narcotics law enforcement at times will cross over city jurisdictional boundaries. By making police in neighboring low-crime, information-poor cities better informed, the high-crime, information-rich cities help to ensure that police from all different cities will

avoid taking enforcement actions that would bring them into conflict (e.g., undercover officers from different cities do not try to arrest each other). In such a case, all police have substantial interests in the coordination achievable through communality. Resources but not interests are concentrated within a portion of such a collective.

Finally, the types of interdependence prominent within a collective may differentially affect the likelihood of communal versus connective goods. Thompson (1967) distinguishes among three types of interdependence. *Pooled* interdependence occurs when each entity independently completes a discrete portion of a whole activity. *Sequential* interdependence exists when one entity must act before the next entity can act. *Reciprocal* interdependence is the most complex, and occurs in the situation in which "the outputs of each become the inputs for the others" (Thompson 1967, p. 55). Connective goods are likely to be favored when interdependence is sequential, and communal goods when interdependence is reciprocal. Neither type of ICI good is likely to be favored in situations of pooled interdependence. In sequential interdependence, such as in a value chain alliance, the communication needs of any entity rest with the stages that immediately precede and succeed it. Thus, directed communication with these adjacent stages may be preferred over broad information sharing. Simultaneous optimization is difficult when dependencies are sequential. In situations of reciprocal interdependence, the need for broad information sharing and feedback within the entire community would favor a communal good. An example of an alliance-based ICI system under conditions of reciprocal interdependence is the Commonwealth Network of Information Technology for Development, which coordinates efforts to use information technology for development within the British Commonwealth (Kumar and van Dissel 1996). Where interdependence is pooled, communication needs are lower and coordination is accomplished as much as possible by standardization rather than communication among the entities (Thompson 1967). Indeed, connective ICI public goods may be least favored in such a situation. For communal goods, under conditions of pooled interdependence the good is the simple sum of the contributed information. It was noted earlier that in such a situation acceleration of the production function might approach zero.

PROPOSITION 22. *The greater the predominance of reciprocal interdependence within a community, the greater the provision of a communal relative to a connective good.*

PROPOSITION 23. *The greater the predominance of sequential interdependence within a community, the*

greater the provision of a connective relative to a communal good.

A considerable opportunity exists for further development of hypotheses that differentiate the processes involved in provision of connective versus communal goods. Propositions 19–23 by no means offer a comprehensive model. They do, however, serve to illustrate the richness of possibilities that await the interested researcher. Appendix 1 offers a compilation of all 23 propositions.

Integrative Example

This section provides an example of predictions based on these propositions for an interorganizational alliance designed to develop and maintain a computer-based information clearinghouse. The alliance links more than 50 law enforcement agencies in a four-county area, including local police departments, county sheriffs, and state and federal agencies. The clearinghouse organization that oversees the effort is under the direction of a board of the police chiefs. It has a small staff of police officers, analysts, computer programmers, and support personnel who provide intelligence information from various sources and from criminal analysis. The organization has several locations that house computers and communication equipment that permit electronic mail, dissemination of information to selected officers, and release of information to the community of users as a whole. The option of whether and how far to share information is under the control of the individual officers and their supervisors. The goal of the alliance is to increase coordination of law enforcement efforts by improving communication among agencies. The initial application of the computer-based information system is narcotics.

The central infrastructure for **physical connectivity** among officers is achieved through equipment provided by grants from the federal government. One of these grants also provides for a small number of local access devices to be installed at a subset of police stations. This represents coverage of a significant cost, since hardwiring for a secure system pushes the cost up to \$50,000 per installation. As of yet, no arrangements have been made to subsidize additional installations, raising the possibility that some departments would bear a significant cost for local access devices.

Social connectivity, largely based on electronic mail, is a challenge. Some jurisdictions already provide computer-based communications for their own cities and their officers are experienced in electronic mail. One jurisdiction, for example, mandates “communication discipline” by requiring that officers check electronic mail

at least twice while on duty. But other jurisdictions are less technologically advanced, and some officers are less skillful and less experienced with the communication discipline needed for achieving the connective good.

To achieve **communality** officers will have to contribute information related to on-going investigations to the alliance database. Common information contributions include names, locations, physical descriptions of suspects, and accounts of narcotics activity in both text and image forms. As the system is currently designed, officers can elect to enter information into a private database on the system and either not share it with others or share it with a selected few. For communality to be achieved, key information will have to be available to other alliance participants and not simply held in private databases.

Officers’ individual gains from their contributions to the connective and communal goods will be determined by the **resources** that they contribute, the **costs** of such contributions, and the subjective **value** of (i.e., interest in) the good. Key **resources** include information of value in resolving criminal investigations, continuing access to information such as that provided by well-placed informants or undercover agents, and the financial resources made available in order to collect and contribute such information. Information resources are measured not only in terms of amount but also in terms of their quality. Information is more valuable when it is timely and accurate. Outdated or inaccurate information may jeopardize investigations and even human lives.

In law enforcement, where misuse of information poses a significant risk to officer safety and to the success of investigations, the decision to contribute resources to the communal good rather than to the connective good will largely depend on the **external confidence** and **trust** of officers. In general, narcotics officers are apprehensive about the security of technologies, especially given the resources and advanced technologies that international drug cartels have at their disposal to intercept information. The clearinghouse system has security measures in place such as encryption and biometric devices in order to prevent unauthorized access to stored information. The clearinghouse organization publicizes the effectiveness of these measures to officers in order to build their confidence in system security. A related problem is the need to trust fellow officers with information widely shared through the clearinghouse system. Narcotics officers are notably suspicious of others due to the nature of their work, more so when they are involved in undercover investigations. Both external confidence and trust levels are likely to vary over time as officers gain experience releasing different kinds of information in different ways,

and as informal networks communicate perceptions about system security and the trustworthiness of officers.

Another factor that will affect agents' decisions to share their information through the system is the extent to which their **key collaborators** also disseminate information through the same system. In general, key collaborators are officers in cities with serious rates of narcotics-related crime. These officers have data and experience with drug interdiction that is critical to officers in other jurisdictions. Without the participation of key collaborators, officers find the effort to share their information futile. Given that the chief and the officers of the largest jurisdiction have been reluctant partners in the alliance, their participation provides a valuable predictor to track over time. The chief of that jurisdiction was replaced recently with one who may be less supportive of the collective endeavor, making the future still more uncertain.

Individual officers will incur **costs** depending on the amount and quality of resources that they provide to the good. Officers are expected to encounter start-up costs in learning to use the system, particularly if they do not have much experience with computers and querying databases through computer networks. As it is currently designed, the human interface of the information system is not user-friendly. Its complexity increases considerably the start-up costs for all end users. Recurring costs involve the time and effort to make contributions and to acquire information, even after learning the basic computer skills. If officers lack access to a local access device, they incur additional costs by traveling to the clearinghouse location, or by requesting assistance from clearinghouse personnel by telephone. Given the officers' preference to be on the streets rather than behind a desk facing a computer screen, high start-up and recurring costs may strongly discourage use of the information system.

Officers will value connectivity and communality depending on their collective and individual interests and their perceptions about the capability of the system to satisfy these interests. One common interest that favors collective action is officer safety. Narcotics officers working undercover run the risk of meeting with other undercover agents and unknowingly assuming they are drug dealers. The result may be a bloody battle of agents shooting other agents. Connectivity and communality may prevent these unfortunate incidents by keeping officers informed of each other's criminal investigations. Personal interests are also expected to affect officers' contributions to different goods. Connective information exchange is likely when officers are rewarded by their jurisdictions according to their individual accomplishments. By comparison, communal information sharing is more likely

when reward structures are based on collective achievement. The reward structure that is currently in place at the federal level creates a disincentive to both connectivity and communality. Federal forfeiture laws require seized assets from drug criminals to be divided among jurisdictions that participate in the investigation. Forfeiture laws have created a history of competition among police departments and fragmentation of investigative efforts to combat crime. Police departments have been known to keep their information private or to withhold recognition of contributions by other departments in order to reap the benefits from resolving a case that involves the seizure and forfeiture of criminals' assets.

As a collective, officers are more likely to contribute their resources to the goods when their contributions are **visible** and **noticeable**. If the clearinghouse system generates summary reports regarding contributions and these are distributed to participants, their supervisors, and the chiefs, then noticeably and visibility will undoubtedly rise. Concrete markers based on communal contributions such as arrests made or volumes of illegal drugs seized can also generate visible effects. Because of the significant confidentiality issues, such information may be scarce or provided only at the collective level.

Currently, there is considerable **interest and resource heterogeneity** across alliance partners. Both are critical factors for the achievement of connectivity and communality, especially at the early stages in production of the goods. They derive partly from differences in narcotics crime rates, financial resources provided to the jurisdiction by the citizens in affluent versus less affluent communities, and personnel resources available to combat narcotics crime. The largest alliance partner has its own narcotics information system and a large narcotics investigative unit. Although that partner's information system is less advanced than the clearinghouse, that partner is relatively satisfied with its own system and, therefore, is not as interested in the communal good. There are other partners that also have major narcotics units working throughout the region, while others with no appreciable narcotics crime devote few personnel or other resources to narcotics investigations. Because crime information is not distributed equally across jurisdictions, no single alliance partner can provide all the needed information, yet a coalition among a subset of the partners might be able to provide at least a critical mass.

Apart from differences in crime rates, interest heterogeneity is a function of **task interdependence** and **geographic dispersion**. Since criminal activity crosses jurisdictional lines, each alliance partner possesses different

pieces of the information needed to solve a crime. Officers are likely to use the connective good in order to exchange valuable information on criminal activity when they know which other partners are working on the same case. Communal sharing of information is more probable when officers do not know who needs their information, as is usually the case during the initial stages of an investigation. Also, since narcotics investigations create reciprocal task interdependencies, communal rather than a connective goods should provide the greatest benefit.

The particular region served by the clearinghouse is very large geographically. Some city jurisdictions are separated by as much as 40 miles. As additional counties join the effort, the reach will extend even further. The more distant the jurisdictions are from each other, the more demand there will be for media to assist communication and coordination, and the more reliance is likely to be placed on common forums such as the clearinghouse for accomplishing coordination across distances. An increase in dispersion with the addition of new alliance partners in neighboring counties is predicted to have positive effects on the production of both connective and communal goods.

The **size** of the collective has already expanded from the founding group in one county to law enforcement organizations in four counties. A long-term plan exists to migrate the system nationwide. The growing number of alliance partners is expected to have a positive effect on resource contributions as the costs decline due to scale economies.

The total amount of resource contributions will depend also on the **density** and **centrality** of the communication network of officers within and across city lines. Dense communication linkages will have positive effects on the amount and frequency of information exchanges in three ways. First, officers who communicate on a regular basis are likely to influence each other and come to share similar attitudes towards the connective and communal goods through social influence processes (Fulk 1993). Second, extended communication among officers may result in a better understanding of the task interdependencies across jurisdictions. Third, ICI systems have been shown to increase the number and breadth of communication contacts (Fulk and Boyd 1991). The information sharing via the computer network is likely to extend beyond the bounds of the clearinghouse system into other media as personal communication networks develop from the impetus of the clearinghouse system. Thus, as officers experiment in increased communication and collaboration, we may see increases in network density that can facilitate further development of the collective goods in the alliance.

Certain alliance partners have assumed a coordinating role for the development of the connective and the communal goods and, consequently, they hold central positions in the communication network (Flanagin 1996). The existence of a coordinating agency that oversees the development of the technical system supporting the collective goods increases the likelihood that the goods will be provided. It is to this extent that centrality will have a positive effect on information sharing.

Over time and growth in the level of the goods, the production functions of both connective and communal goods should accelerate. As noted above, the initial contributions will be more difficult to obtain than later ones, especially for the communal good, because the database will be more attractive at later points when more partners have contributed information. The early stages may find most officers keeping their information private or sharing it with selected others, thus contributing to the connective good. If data on message traffic and contributions to the database were captured over time through the computer system, the shape of the function so produced would rise slowly then turn more sharply upward. Given that the clearinghouse agency supports an intelligence unit with the mission to analyze the data contributed to the collective good, the value of the database is expected to increase as new data is created through the analysis of existing contributions. In the case of an unsuccessful system, the function would appear more like an inverted U with a maximum value too low to constitute a collective gain. Increasing use may appear to be productive up to a point, but it finally will not pay off. A deciding factor for the production of the collective goods will be the repeated information contributions to the goods. Failure to provide timely information on a regular basis will diminish the value of the goods to officers who seek up-to-date information for their investigations.

Overall, the alliance that produced the clearinghouse is a rich illustration of opportunities for success or failure of collective action via ICI systems. It can be considered a conservative test in that there are a number of serious obstacles to a successful alliance. These include: (1) concerns regarding confidentiality and officer safety, (2) a history of failure to cooperate and communicate across jurisdictions, (3) extensive laws regarding use and information sharing about private citizens that rigidly control what information may be input into the alliance database without violating citizens' rights, and (4) disincentives to cooperation in federal asset forfeiture laws. At the same time, there are several uncommon factors that favor such an interorganizational alliance: (1) a shared code, mission, and goals among participants, (2) heavy subsidization of initial hardware, (3) the support from the top of

the organization (police chiefs and sheriff) in all partner jurisdictions, and (4) strong champions of the cause among several of the chiefs.

Conclusions and Further Directions for Development

Much additional research and conceptualization is needed in the application of public goods premises to alliance-based ICI systems. This final section describes a few directions for further work in an attempt to identify areas where public goods theories deserve more detailed attention. The core challenge is to identify modifications to public goods theory as applied to alliance-based interorganizational communication and information systems rather than traditional material goods. Such further study may also offer new insights for the theories themselves.

Jointness of Supply

In order for conditions of jointness of supply to exist for a connective good, one person's use of the ICI system should neither prevent other partners from using it nor consume resources in such a way that they are unavailable to others. This condition might be compromised, for example, if system capacity is insufficient to meet the volume of communication needs. For a communal good, one person's use of information should not inhibit its use by others or its worth to them. This condition would be violated if a user were able to remove valuable information from the database so that other users could not access it.

Impossibility of Exclusion

When infrequent users or expensive connections are excluded, as in cases of optimal connectivity, impossibility of exclusion is compromised in an ICI system. As distinct from cases where individuals choose not to consume connective or communal goods, security restrictions on access either to network systems or to certain information or accounts in database systems similarly imply that the good is excludable. Because such exclusion is not uncommon in ICI systems, further attention should be devoted to the scope of nonexcludability in connective and communal goods.

Free riders are a particularly interesting topic to study. Although one could free-ride on the physical connection, it is not possible to free-ride on social connectivity inasmuch as one must be connected in order to receive connective benefits. Free-riding certainly appears to be possible with respect to communal goods. Yet, the failure of free riders to help provide a public good does not mean their actions are not valuable to providing other public goods. From the integrative example, imagine agents in a jurisdiction who receive information from the database

but do not contribute. If the information they receive prevents them from acting in ways that threaten the safety of officers who do contribute, their role as free riders may actually be quite valuable. Otherwise, officer safety might be threatened when undercover agents from different jurisdictions confront each other unaware of each other's operations. It was stated earlier that ICI system users pay some costs even to acquire information. It would be reasonable to regard these payments as contributions toward public goods that derive from information sharing. The situation is similar to that of the undercover agents who free ride on the public good of communality but pay the costs of acquiring database information. In each case, those who pay to acquire the information contribute to the derived public good of officer safety.

Divisibility of the Good

Marwell and Oliver's (1993) theory describes some goods as being divisible, as for example the books in a public library. Divisibility of ICI goods offers some possibility for viable coalitions to create a critical mass for a subset of the collective. For connective goods, a subset of persons might develop their own electronic mail network, even though most others have not adopted it, as was common in the early days of the medium. Alternatively, individuals might compromise nonexcludability by withholding their electronic mail addresses from any but a select subset of system users, making it more difficult for others to contact them.

For communal goods, a subset of alliance partners with common interests might create a database that meets their own needs, but not the needs of the broader collective. Limited access rights, as in tiered bulletin board systems, could create the same effect. The net effect in either case would be to exclude some current and prospective users from the full benefits achievable through communality, resulting in a reduced form of the good.

Privatization of the Good

The example of the clearinghouse illustrates Sweeney's (1973) contention that private goods may facilitate the realization of a public good in large collectives. The creators of the clearinghouse believe that if officers are able to maintain private databases within the same ICI system, they will be more likely in the long term to contribute information for the communal record. If the communal contributions do not naturally evolve, some sort of coordinating authority may be necessary to induce individuals to publicize their information. But the ability to maintain some private information on a system that permits relatively easy transfer of information to the public record may enhance the probability of making the private

information public in the future on an individual user's own initiative.

Conclusion

Public goods theory offers valuable insights for understanding alliance-based ICI systems, and connectivity and communality are important public goods arising from collective action. Much can be learned about collaborative work and alliance-based ICI systems by the application of public goods theory and by seeking out anomalies as the theory is applied. Thus, the public goods framework serves to illuminate the intricacies of alliances based on ICI systems, offering a rich intellectual heritage and fascinating avenues for research.

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Appendix 1. List of Propositions

PROPOSITION 1. *Production functions for connective and communal goods in alliance-based interorganizational ICI systems are accelerating.*

PROPOSITION 2_(a-c). *Over time, increases in the provision of connectivity through an alliance-based interorganizational ICI system will be associated with increases in organizational effectiveness in the form of overall: (a) quality of information available, (b) amount of information generated, and (c) member satisfaction with process.*

PROPOSITION 3_(a-c). *Over time, increases in the provision of communality through an alliance-based interorganizational ICI system will be associated with increases in organizational effectiveness in the form of overall: (a) quality of information available, (b) amount of information generated, and (c) member satisfaction with process.*

PROPOSITION 4. *Over time, increases in participant interests in an alliance-based interorganizational ICI system will be positively related to increases in participant gains.*

PROPOSITION 5. *Over time, decreases in the participant start-up costs associated with using a new alliance-based interorganizational ICI system will lead to increases in individual participant gains.*

PROPOSITION 6. *Over time, decreases in the participant recurring costs associated with using a new alliance-based interorganizational ICI system will lead to increases in participant gains.*

PROPOSITION 7. *Over time, increases in individual external confidence will lead to increases in individual resources contributed.*

PROPOSITION 8. *Over time, increases in individual trust will lead to increases in individual resources contributed.*

PROPOSITION 9. *Over time, increases in the anticipated and/or actual use of the system by a participant's key collaborators will lead to increases in participant resources contributed.*

PROPOSITION 10. *Over time, across participants in ICI systems, greater interest heterogeneity will be associated with increases in the amount of resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 11. *Over time, across participants in ICI systems, when controlling for limits imposed on contributions, greater resource heterogeneity will be associated with increases in the amount of resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 12. *Over time, higher correlations between resources and interests where resources and interests are heterogeneous will be associated with increases in the amount of resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 13. *Changes in the relative levels of perceived task interdependence between members of different organizations will be associated with increases in interest heterogeneity, leading to greater resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 14. *Geographic dispersion of organizations will be associated with increases in interest heterogeneity, leading to greater resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 15. *Over time, increases in the noticeability and visible effect of contributions to an interorganizational ICI system will be associated with increases in the amount of resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 16. *The greater the costs of information infrastructure for an interorganizational ICI system, the more positive will be the relationship between size of the collective and the amount of resources contributed toward the level of connectivity and communality within an interorganizational ICI system.*

PROPOSITION 17. *Over time, increases in the density of extant communication networks for each organization will lead to increases in the amount of resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 18. *Over time, increases in the centrality of communication networks for each organization will lead to increases in the amount of resources contributed toward connectivity and communality within an interorganizational ICI system.*

PROPOSITION 19. *The lower the individual trust in community members, the greater the individual's resource contributions to a connective relative to a communal good.*

PROPOSITION 20. *The greater the density of communication networks within a community, the greater the provision of a connective good relative to a communal good.*

PROPOSITION 21. *To the extent that resources and interests are heterogeneous and there exists a portion of the public wherein the highest levels of resources and interests both are found, the provision of a connective good is more likely relative to the provision of a communal good.*

PROPOSITION 22. *The greater the predominance of reciprocal interdependence within a community, the greater the provision of a communal relative to a connective good.*

PROPOSITION 23. *The greater the predominance of sequential interdependence within a community, the greater the provision of a connective relative to a communal good.*

Endnotes

¹Marwell and Oliver (1993) employ a number of different forms of this equation. For example, g_i sometimes carries the argument r and at other

times carries the argument R , depending on whether the individual acts without (r) or with (R) knowledge of others' decisions. Marwell and Oliver do not present the general form to include both arguments as it is shown here.

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