Measuring Firm Performance at the Network Level: A Nomology of the Business Impact of Digital Supply Networks

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ABSTRACT: For decades, information technology has been posited to have a major impact on firm performance. Investigations into this line of inquiry have almost always used constructs related to individual firm performance as their dependent measures, an approach that made sense under historical economic conditions. In recent years, however, value chains are giving way to digital supply networks with electronic interactions between tiers in the flow of goods and services. Such an environment makes it imperative to develop sophisticated measures of the performance of entire networks of firms, as opposed to individual firm performance.

Using game-theoretic concepts, this paper explores several dimensions of networked organizational performance as a construct, as a set of measures, and as a construct within a nomology. It describes a program of research in which some empirical validation has already been completed and other work is now underway. We first validate measures for a dyadic view of network performance, followed by an *n*-firm perspective.

KEY WORDS AND PHRASES: business networks, e-business, e-commerce, firm performance, supply chains, supply networks.

The Problem

BEGINNING WITH THE WIDESPREAD COMPUTERIZATION of business in the 1960s, information technology (IT) researchers have focused their attention on the many ways in which IT can impact individual firm performance. This work has been undertaken in a variety of settings as diverse as displaced benefits at the national level (i.e., IT benefits are not enjoyed by firms, but by other stakeholders such as consumers)[1] and IT effects in specialized locales such as hospitals [22]. At this point in the maturation of the IT field, numerous measures of individual firm performance have been developed and related to IT antecedents. With value chain relationships enabled through IT investments, for example, the potential return can be substantial. The belief that IT positively affects individual firm performance has been heavily debated and studied within the economics of the information systems (IS) community [3, 9, 10, 11, 12, 13, 18, 47, 48].

In spite of the usefulness of this intensive activity and the insights that the work has given the field, a sea change has occurred in how performance needs to be measured. This sea change is the movement from an economy of traditional, physically oriented firms to an economy where electronic connections are both the means of communication and the means of production and distribution. The setting has been termed "Net-enhanced organizations" in a "networked economy" [86]. Another term that is often used is e-commerce.

What is the networked economy? The networked economy describes alliances of firms that thrive on digital supply networks. These networks exchange information to coordinate the production and distribution of goods and services, and, in the best of all possible worlds, this interactive flow of information among member firms will result in efficient and effective supply-and-demand revelation. The value of this computerized exchange is so important that each member firm's prosperity may intimately depend on it. In fact, the sources of firm value and competitive advantage are embedded not just in individual firm resources and capabilities but also in the resources and capabilities that are embodied in supply networks [53]. The potential of supply networks as a source of value is enhanced by IT innovations that support different forms of network configuration and interaction between network members.

Unfortunately, digital supply networks across industries and sectors suffer from poor and inexact information, delayed sharing of information, and, in the worst case, lack of information where and when it is needed most. Mediated sharing of information leads to reinterpretation and distortion of important market signals, such as shifts in demand and supply conditions. Such incomplete, distorted, and delayed information sharing in digital supply networks leads to uncoordinated decisions that result in bloated inventories or stock-outs [81, 91]. In fact, the fragmented structure of supply networks even distorts stable demand signals associated with long product life cycles, creating systemwide inefficiencies [27, 49, 58]. The problems created by inadequate supply network capabilities are exacerbated in supply networks that are characterized by high levels of demand and supply uncertainty [57]. Only too often companies report large proportions of orders unfilled and lost to competition or they report bloated inventories that need to be written down [57].

Firms have been applying IT innovations to improve their supply chain processes, but there is very limited theory to guide these initiatives. Most studies that have examined the impact of innovations applied to supply chain processes have been conducted at the firm level, as most constructs pertaining to capabilities and performance have been conceptualized at the firm level. Recent empirical evidence emerging from the study of supply chain practices undertaken by individual firms suggests that IT innovations applied by them to enhance information sharing and coordination with their partners improve certain firm-specific processes [30]. However, the conceptualization of constructs, development of measures, and design of the research at the firm level constrain our ability to develop and test theory about the behavior and performance of supply chain networks, essentially the network-level phenomenon.

To deal with this serious problem, this research proposes to create and test measures for the performance of configurations of multitiered digital supply networks. The major research questions include: What are the defining characteristics of such interfirm networks? How has networked organizational performance been conceptualized and measured to date? Where should we direct our energies in the future in order to capture performance at this level?

There is a pressing need to move forward with measuring performance at a networked organizational level, and the present paper contributes to this critical requirement. The initial step in reconceptualizing networked organization performance is to define it, and then test it in its simplest network form, the dyad or two firms. These are reported in this paper. Further steps involve conceptualizing more complex networked organization forms such as triads, quadrads, and so on, and then positing a means of gathering data to test their measurement properties. These further steps are outlined in the paper and guidelines offered for how these can be actualized.

Conceptualization of Networked Organizational Performance

THE OUTCOME VARIABLE "PERFORMANCE" can be measured at a variety of levels. As DeLone and McLean [20, 21] point out in their IS Success Model, there are in IS research at least the individual and organizational levels of performance. Between these two levels are groups of varying sizes, up to and including, presumably, business units and divisions. Interorganizational performance—that is, the performance of networked organizations (NetOP)—is obviously a network measure, one that captures output activity at that level at which the researcher defines the network of organizations.[2] Table 1 shows the relevant levels of performance with respect to this paper.

Drilling down into the networked organizational level (NetOP), this performance construct can be conceptualized via three perspectives. First, as Figure 1 shows, there is a straightforward numbered perspective. From this standpoint, a network can be defined as any two or more interacting firms. The simplest network is a dyad or a network with two nodes. Conceptually, the largest network is a set of all existing firms, assuming that, in a truly free market global economy, each firm must be connected to at least one other firm, and that firm to other firms, and so forth. Given that it is not feasible to measure, or perhaps even to theorize about, a network on such a universal scale, we are forced to temporize and to work with smaller groups of firms or nodes. An intermediate conceptualization, for example, may be bounded by geography or industry. Other bounds may be tiered associations of suppliers, component assemblers, distributors, and retailers that are linked directly or indirectly together.

The first, numbered perspective in Figure 1 leads to simple or derived measures that are concerned with the *absolute performance* of a defined set of partner firms and their *performance relative to each other.* The performance of a supply network set of X members can be contrasted with another supply network set of Y members in nominal terms by aggregating tangible and intangible performance metrics associated with individual firms. Measures such as standard deviation and covariance of performance measures across firms captures the performance homogeneity of member firms in a defined supply network set.

The second "tiered" perspective involves network tiers, into which are partitioned activities in the value chain by related activities. In a multitiered supply network, for example, one set of tiers will provide raw materials, another set will manufacture whole products or components, a third set will assemble these, a fourth set will wholesale them, and so forth. This can also be thought of as vertical specialization. The role of tiers in supply networks motivates the development of measures that capture the nominal performance of a supply network by tier, relative performance of member firms in a tier, and relative performance of member firms across tiers. Tier-focused nominal performance measures enable between-tier comparison across supply networks, whereas tier-focused relative performance measures enable within-tier comparisons of the performance homogeneity of member firms.

Finally, the third "layered" perspective involves a layering of individual firms, depicting whether they interact directly with firms in other tiers, or whether these ties are indirect. Direct ties, such as relationship 1 and 2 in Figure 1, cross only one level

Table 1. Networked Organizational Performance Placed in Context of Other Levels Measuring the Performance Construct

Performance level	Description of performance	Sample references in literature
Individual performance	Examines the task outputs of individuals in organizational settings; measures include time to complete, quality, and so on.	Torkzadeh and Doll [89]
Group performance	Looks at group outputs; measures include consensus, quality of decisions of decisions, and so on.	Trauth and Jessup [90]
Organizational/firm performance	Reports on firm or organizational outcomes; measures include return on investment (ROI), profits, inventory turnover, and so on.	Devaraj and Kohli [22]
Networked organizational performance	Aggregates firm-level outputs to a network configuration; directly gathers data about specific network outcomes; may be thought of as the performance of an entire set of networked organizations or an entire "system" of firms; measures include network ROI or network inventory turnover.	Groves and Valsamakis [41], but no work in the IS field to date

and one layer. These can be thought of as strategic alliances and partnerships. Indirect ties such as relationship 3 occur when firms are not immediately dependent on firms that supply the suppliers, and have alternative sources. The choice of ties represents a tradeoff in required relational investments and conceivable benefits that are accrued [43]. This dimension is also a matter of control and task interdependence. The role of direct ties and indirect ties in supply networks motivates the development of measures that capture the nominal performance of the network by layer and the relative performance of members within layers and across layers.

Each of these perspectives can be used as a lens to investigate networks of two (dyad), three (triad), four (quadrad), five nodes (quintrad), and up. Once an outer network boundary is defined, the researcher can model a variety of networks by grouping the members into dyads, triads, and so on. Figure 2 shows a basic tiered network structure with a single Tier 0 partner, and three each at Tiers 1 and 2. Figure 3 depicts 53 illustrative interactions from the standpoint of the numbered perspective. The network structure as shown permits direct interaction between tiers that are one step removed from each other, and indirect interaction between tiers that are two steps removed. Since the firms are also categorized by tier and layer, perspectives 2 and 3 can also be analyzed.

Next, we examine the established theory bases that inform our construct development, including Galbraith's [33] information processing theory and Granovetter's

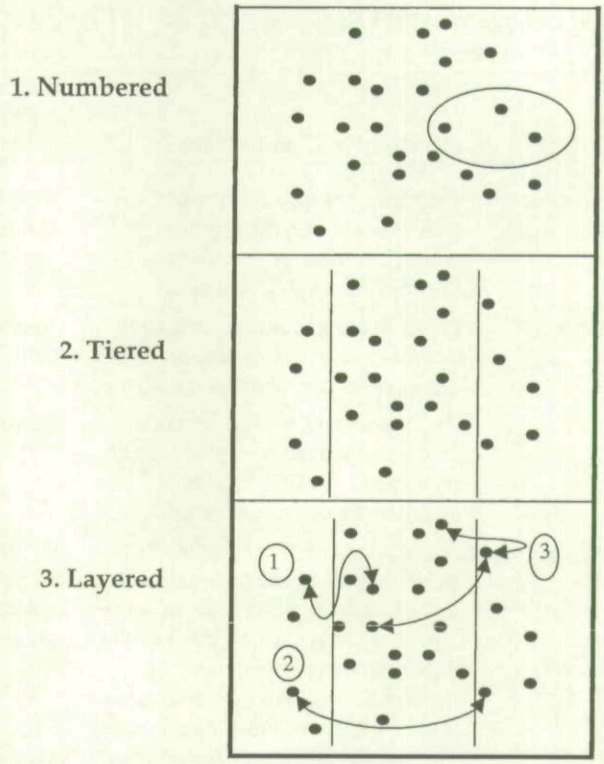


Figure 1. Three Perspectives on the Performance of Networked Firms

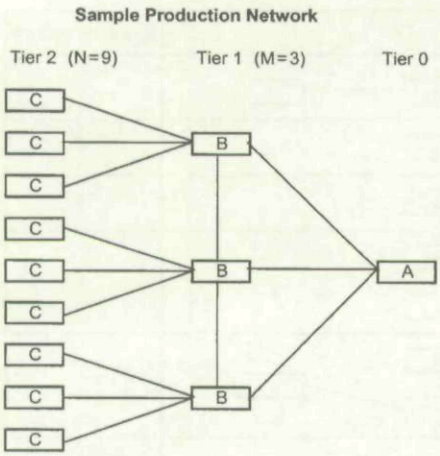
[39] strength-of-weak-ties theory. The nomology of these theories supports the notion that independent variables, such as information sharing, network flexibility, and interactivity, will enhance service levels and lead to lower peaks and valleys in organizational inventories and productivity, and, through such means, ultimately improve networked organizational performance. Digital supply networks are intricately tied to these features, of course.

Theoretical Justification for this Conceptualization of NetOP

The nomology of NetOP can be elucidated via several theory bases and models, as shown in Table 2. The important point behind all of these models is that they argue for the conceptual and logical links between size and the complexity of network nodes and outcomes. What this means in terms of measurement is that the construct of network performance is better realized as a reflection of the structure of its nodes (tiers and layers) as well as of sheer numbers.

In the work of Galbraith [32, 34], Malone [64], Malone and Rockart [65], and Simon [83], a firm is depicted as a distributed system designed for information processing. The purpose of any collection of local actions is to act in concert for a global optimum. Correspondingly, the purpose of any collection of organizational elements,

Network Structure



Nodal Information

Nodes		# of Nodes
Tier 0	A	1
Tier 1	B	3
Tier 2	C	9

Assumptions about Internodal Ties:

A) Tier 0 nodes interact with Tier 1 nodes; and Tier 1 nodes interact with Tier 2 nodes.
B) There is no direct interaction between Tier 0 and Tier 2 nodes.
C) Interactions between Tier 2 nodes are not considered.

Given the above nodal information and the assumptions about internodal ties, the following interactions are feasible.

-- Dyadic interaction
  -- between nodes in the same tier;
  -- between nodes in two tiers;
-- Triadic interaction
  -- between nodes in the same tier;
  -- between nodes in two tiers;
  -- between nodes in three tiers;
-- Quadratic interaction
  -- between nodes in two tiers;
  -- between nodes in three tiers;
-- Five-nodal interaction
  -- between nodes in two tiers
  -- between nodes in three tiers.

Figure 2. Basic Structure of Network Interactions (Configurations)

as in a network of firms, is to overcome the complexity of the organizational connections in order to achieve maximal efficiencies. Complexity, hence, is a matter both of numbers and, importantly, of the intricacies of interactions between network nodes.

According to coordination theory, both internal and external uncertainties need to be accommodated in the communicational processes of organizations [63]. The adaptability of networked linkages allows a firm to deal with high environmental uncertainty [32, 34], even though this may not be the most efficient form of communication. Thus, it is not just the number of elements that is critical in a network analysis but also the way in which the network is architected.

Some of the concepts of information processing and coordination theory have been applied to supply chain coordination problems through what we call, loosely, information sharing models. Lee and Clark [56] investigated the upstream order variance amplification, a phenomenon popularly known as the bullwhip effect. The bullwhip effect characterizes most supply chains across industries. This variance amplification has detrimental performance impacts, as it is directly proportional to inventory inef-

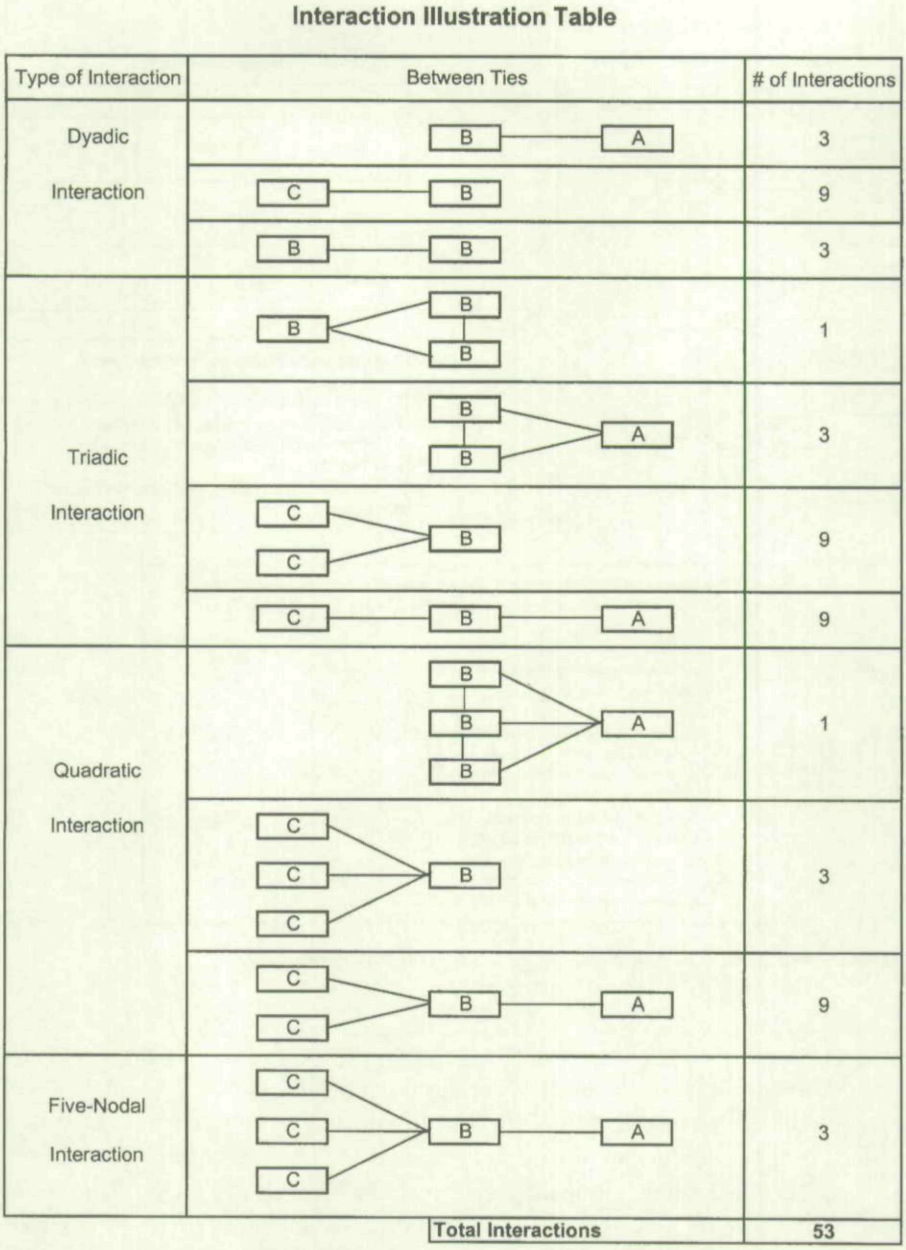


Figure 3. Illustrative Network Configurations Within Overall Network Boundaries

ficiencies experienced by member firms of a supply network. Mathematical models have been proffered to show that upstream order variance amplification in an n-tiered supply chain is a positive function of the number of tiers [56]. In addition, structural issues that impact information flow have a profound impact on the bullwhip effect. Specifically, decentralized demand information across the supply chain and delayed

Table 2. Theoretical Bases for a Nomology of Networked Organizational Performance

Theory bases/models for NetOP nomology	Nomological links discussed	Relevant citations
Information processing theory	Well-chosen, well-ordered organizational elements lead to higher performance.	Galbraith [32]; Galbraith [34]; Malone [64]; Malone and Rockart [65]; Simon [83]
Coordination theory	A reasoned architecture of elements is critical to higher performance.	Malone et al. [66]
Information sharing models	Number of tiers and kind of information sharing within tiers affects performance.	Lee and Clark [56]; Simchi-Levi et al. [82]; Sahin and Robinson [81]; Chen et al. [16]; Hariharan and Zipkin [45]
Sociological network theory (strength of weak ties)	Bonds between players lead to more or less frequent information exchange, with implications for performance.	Grabner [38]; Granovetter [39]; Parsons [74]
Game theory	Symmetrical information exchanges can maximize gains of the entire system.	Nash [70]; Friedman [29]; Lave [55]; Plott [75]
Transaction-cost economics	Asset specificity through process customization (dependence) leads to customized marketplace relationships and higher performance.	Lohtia et al. [61]; Williamson [94]; Dyer et al. [26]

upstream information transfer about demand signals increase the upstream order variance amplification [56, 82].

In an extensive review of the digital supply chain coordination literature, Sahin and Robinson [81] classify three dominant types of supply chains. First, there are supply chains where there is no information sharing and no system coordination. By developing an analytical model of a two-stage serial supply chain with no information sharing and no system coordination, Chen et al. [16] show that firms experience the bullwhip effect to a great extent, with an upstream amplification of order variation. Their analytics show that the greater the level of demand uncertainty, the greater the order variation amplification in these supply chains. Second, there are supply chains with partial and full information sharing and no system coordination. By utilizing electronic data interchange (EDI) and other advanced IT, firms participating in these supply chains share real-time POS, order, and inventory data. The availability of real-time information on key issues enables each firm to adapt its decisions and actions and enhance its responsiveness.

Offering another information sharing model, Hariharan and Zipkin [45] make a distinction between demand lead time, which is the time duration from when the customer places the order until the specified delivery due date, and supply lead time, which is the supplier's replenishment lead time from the vendor. Their analytical results suggest that reductions in demand lead times have the same effect as reductions in supply lead times.

Moreover, there are supply chains that are integrated tightly through full information sharing and system coordination. Full information sharing, accompanied with coordinated decision-making, can result in significant performance improvements. For example, Fry et al. [31] show that vendor-managed inventory systems under full information sharing can outperform retailer-managed inventory systems that use periodic review and order up to policy.

The sociological network theory perspective has investigated the impact of the structure of interaction between firms in complex networks on their behavior and performance. Sociological theories define networking as a form of socialization, where network links are subject to direct or indirect ties, strong or weak bonds, loyalty or antipathy, and honesty or deceitfulness [38, 39, 74]. This is true in so many circumstances that where hierarchies tend to have few, direct ties, the network will exhibit greater heterogeneity in the frequency and type of communication between nodes, making it inherently more dynamic and agile in uncertain environments.

In contrast, closed-loop networks that are characterized by repeated interactions and direct ties between members exhibit mutual trust and deep information sharing. This theory base suggests that the nature of ties, direct or indirect, weak or strong, affects network behavior and performance. These theoretical ideas imply not only that network performance is an important concept but that different dimensions of network performance are required for a complete conceptualization of the construct.

Theories of weak–strong and direct–indirect ties address information sharing behavior between partners in a network. In addition to the magnitude and content of information shared, the symmetries of information among partners have always been of concern in the major theories that explain information sharing among partners in a supply network. The most widely disseminated insights related to information sharing behaviors derive from game theory [54, 70] although agency theory [79], transaction-cost economics [92, 93, 95], and property rights theory [46] also embrace information symmetries as a focal variable.

John Nash [70], one of the major game theorists, stressed cases where symmetrical, cooperative behavior between profit-maximizing agents is superior to competitive behavior. Commonly illustrated in the example of the prisoner's dilemma, where two captured prisoners can reduce their overall sentences if they collude, symmetrical information sharing has been repeatedly verified not only through simulations but in empirical work [29, 55, 75]. Therefore, not only does a nominal level of information sharing in supply networks affect performance, but symmetry of sharing does as well, since both magnitude and symmetry of information sharing facilitate convergence toward a Pareto optimal outcome.

Nomology for Digital Supply Networks: The Linkage Between Information Sharing and NetOP

Information Sharing

Information sharing has long been recognized as an underlying construct within the IS community [4, 5, 7, 8, 66]. For the purposes of this study, an examination of the relationships, or partnerships, within the network gives rise to a greater understanding of the symmetric information sharing phenomenon as previously employed within the community [18, 24, 40, 50].

It has been noted that partnering relationships, or alliances, require some degree of equal cooperation, otherwise the nondominant partner might lose interest [2, 77]. Although an extreme example, this highlights the importance of maintaining some degree of equality within relationships. von Neumann's game theory provides the basis for modern theoretical work in the field of cooperative strategies [76]. Nash [69] and Thomson [88] advance the notion of the bargaining problem at the core of a two-person bargaining situation, where the individuals involved have the opportunity to collaborate for mutual benefit in more than one way. Nash [70] also developed the theory of noncooperative games, a contradistinction of the von Neumann and Morganstern *n*-person cooperative game, where participants are assumed to act independently, absent collaboration. Axelrod [2] furthered von Neumann's work, focusing on the development of the theory of cooperation with the introduction of the concept of the prisoner's dilemma providing a basis for explaining the existence of symmetric information sharing relationships; that is, firms develop information sharing relationships in an effort to achieve certain gains.

As detailed in Table 3, we operationalize information sharing in networks as the extent to which participating firms share information within the network as well as the symmetry in said practices. Subsequently, we propose measuring the degree of firms' information sharing within a given network and the symmetry in information sharing among network participants.

Dependence

In its conceptualization of asset specificity, transaction-cost economics [94] provides one basis for looking at dependence and process customization within network relationships. Physical or human investments are dedicated to a specific partner, and redeployment entails considerable switching costs to an organization. Asset specificity ultimately increases the dependence upon the partner and serves to escalate the transaction-cost economic situation [35]. Where these assets are dedicated to a specific relationship with minimal or no value outside of the relationship, transaction-specific assets can be said to exist [61, 94].

Table 3. Nomology of NetOP: Constructs and Measures

Construct	Definition	Possible measures
Independent variables (IV)		
Information sharing	Extent to which firms share information and the symmetry of this sharing in a network.	Degree of information sharing and the symmetry of sharing with partners in the supply network.
Dependence	Extent to which firms are dependent upon a network—that is, extent to which they have invested time, effort and finances in customizing linkages.	Degree of process customization in participating in the network and potential switching costs involved in replacing network with alternate sourcing for products or services.
Dependent variable (DV)		
Networked organizational performance (NetOP)	Aggregate performance of digital supply network partners.	Symmetry and degree of inventory turnover; days on hand of inventory; net trade cycle; absorption margins for inventory, fixed assets, and accounts receivable; working capital efficiency; and operating margins.

The level of dependence that exists within network relationships can be operationalized from an economic perspective through an examination of the presence, perceived or real, of switching costs [51, 52, 59, 71]. Where the client acknowledges minimal or no switching costs in its continued patronage of the vendor, the switching costs can be said to be low. Where the client acknowledges significant switching costs in its discontinued patronage of the vendor, the switching costs can be said to be high. The extent of switching costs faced by the client depicts their dependence, in effect, upon the relationship [72].

Moreover, the level of dependence within these relationships can be viewed in terms of the level of process customization that exists between parties and categorized as generic, configured/standardized, or customized. When the degree of process customization is generic, there is a mutual acceptance of established, default information exchanges; for example, many of FedEx's clients use FedEx's basic online tracking application to determine package delivery [68, 80]. When the degree of process customization is configured/standardized, information exchanges occur within parameterized conditions—that is, the employment of XML standards in data exchanges, as is the case for certain FedEx clients [80]. Finally, when the degree of process customization is customized, highly specialized built-to-order information exchange solutions exist—that is, custom EDI routines. At the customized level, Sun Microsystems Inc.'s Asian subsidiary has developed highly tailored supply chain logistics systems with DHL Worldwide Express in an effort to achieve cost savings and increase response times [67].

As detailed in Table 3, dependence is the extent to which firms are dependent upon a network, through their investments in time, effort, and finances in developing, or customizing, linkages. Here we propose measuring firm degree of customization as well as the switching costs involved in replacing the network with alternate sourcing for products or services.

As noted by Dyer and Singh [25], investments in relation-specific assets, such as customized processes, generate relational rents. These rents are contrasted against brokerage rents associated with short-term, transaction-focused, market-mediation processes. Given that dependence characterizes investments undertaken by network members to support customized interaction and collaboration, we postulate that increased dependence enhances network organizational performance.

Given our earlier discussion of the NetOP, information sharing, and dependence constructs, we offer the following propositions for this NetOP nomology:

> *P1: Greater information sharing in a digital supply network, which encompasses both the extent and symmetry of sharing, leads to higher networked organizational performance (NetOP).*

> *P2: Greater dependence of a digital supply network, which encompasses both the extent and symmetry of dependence, leads to higher networked organizational performance (NetOP).*

Methods

Steps Toward Developing Constructs and Measures of Performance for Networked Organizations

AS THE UNIT OF COMPETITION HAS EXPANDED from firms to supply networks, there is a need to develop constructs and performance measures for networked organizations. There are compelling reasons to develop these research constructs and their measures for networked organization performance in two major steps or stages. The simplest form of the relationship between firms is the dyad. The firms may be long-term partners or short-term client and vendor, but the nature of the bond is one-on-one. These dyads represent a network configuration at the most elemental level. Step 1 is to develop and test measures of the networked organizational performance construct at this level.

More complex forms of networked organizations include triads, quadrads, and higher-order nodal links. Whereas the construct of networked organizational performance transcends the number and nature of such connections, a different approach to measuring performance of these networked organizations is required. Step 2 has not been carried out yet and is an agenda for future research. We can characterize the anticipated methodological issues in this next stage and some possible solutions. We discuss these issues and solutions for the benefit of researchers besides ourselves who wish to pursue the conceptualization and measurement of the performance and its nomological net for complex networked organizations.

Numbered Perspective for Network Performance Constructs and Measures

Adopting perspective 1 to study network performance, we first examined the network dyadic performance of one of the world's largest logistics vendor and its customers in an empirical field study. The research used an electronic survey to measure the outsourced supply chain management relationships between a Fortune 500 logistics vendor and nearly 80 of its clients ($N = 156$), focusing on mutual strategic information sharing practices and subsequent impacts upon both parties. These impacts were conceptualized as: (1) tangible effectiveness performance outcomes and (2) intangible efficiency performance outcomes. At the center of this examination was the notion of symmetry in the information sharing practices within the relationship and the subsequent symmetry in the performance. Figure 4 highlights the distinction between traditional models and symmetric models.

Traditional monadic models consider either one side of the business relationship or the other—that is, client or vendor. Symmetric models, on the other hand, consider the balance in information sharing and performance. Please note that in measuring only symmetry in a business relationship, the exact extent of the construct is lost—as, for example, where there is a low degree of sharing or low levels of performance. Degree-symmetric network performance, as shown in Figure 4, captures both the balance and depth of the relationship.

Using the numbered perspective (i.e., an interfirm relationship of two firms, or dyads), we surveyed vendor and client partners with respect to outcomes of specific tangible, effectiveness and intangible, efficiency. Existing literature [1, 6, 11, 12, 19, 27, 42, 44, 48, 62, 78, 87] provides insights for developing a set of outcomes from which measurement items can be derived. The study determined applicable performance items for the specific relationship under examination. These items are summarized in the following tables of performance outcomes. These performance items were field validated for content with both the client and vendor via senior account managers and two client contacts, all of whom had five years or more tenure in their positions and whose organization used the vendor and at least one competitor. The items were measured along a seven-point scale [73], from "never" to "always."

Participants could decline to respond to any performance item for which they were unsure of the rating. Tangible, effectiveness outcomes were conceptualized as consisting of elements reflecting increased productivity and lower operating costs. Intangible, efficiency outcomes reflected reduced workflow; more timely information; improved resource control; increased flexibility; improved production planning; and improved asset management. The final version of matched pairs of specific performance items for the client and vendor surveys appears in Table 4.

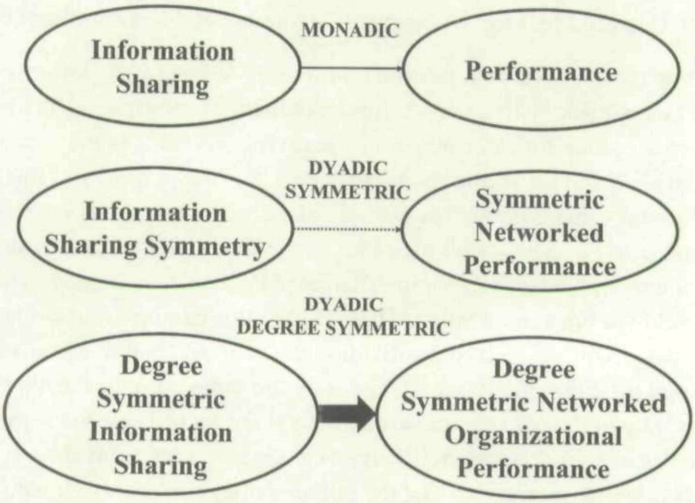


Figure 4. Monadic Versus Dyadic, Symmetric Versus Nonsymmetric, Degree Versus Non-Degree Models

Table 4. Performance Outcome Items

Code	Performance types
PT1	Increased productivity
PT2	More timely information
PT3	Lower operating costs
PT4	Improved resource control
PT5	Increased flexibility
PT6	Improved production planning
PT7	Improved asset management
PT8	Reduced workflow

Omnibus Performance Items

In addition to the survey of clients and the vendor (dyads) on these specific performance items (PT1–PT8), omnibus items were developed on a seven-point Likert scale from "strongly disagree" to "strongly agree." The Likert statements were:

> *P1: The client has realized substantial improvements in tangible performance outcomes, that is, things that are easily measurable or discernible.*
>
> *P2: The client's overall economic situation has improved as a result of its relationship with the vendor.*
>
> *P3: The client has realized substantial improvements in intangible performance outcomes, that is, things that are not easily measurable or discernible.*

Developing Derived Measures of Information Sharing and Network Performance

To show how measures of both information sharing and network performance were derived, let us consider two examples in the domain of information sharing. Client value or vendor value for information sharing, CV_{IS} and VV_{IS}, is the measure of the parties' sharing behavior within the relationship. For the purposes of this example, the client/vendor value is defined as the ratio of shared information to the total potentially available to be shared with the other party. This study examines the relationships' symmetry value for information sharing, SV_{IS}, which is defined as the ratio of the client value to the vendor value. Therefore, in this example, each relationship's symmetry value will be derived by dividing the ratio of shared information to the total potential for either the client or vendor by the same ratio for the other party.

The derivation of the relevant transformations is shown in Table 5. Please note that, irrespective of scaling, the derived variable *DSV* will vary from 0 to 1, with low values indicating asymmetry or low magnitudes of symmetry. High values, on the other hand, represent high levels of symmetrical performance. Finally, intermediate *DSV* will reflect either asymmetry or low magnitudes.

Table 6 presents an example of information sharing between client and vendor. It details the amount of information actually shared by each party with the other as well as the total potential information available to be shared within the relationships.

In Table 6, consider a client that shares 2 of 10 potentially available types of information. Dividing the number shared, 2, by the total potentially available, 10, yields a client value of 0.2. For a vendor that shares 7 of 9 potentially available types of information, the vendor value would be 0.78. The relationship symmetry value can be derived by dividing the client value, 0.2, by the vendor value, 0.78, for a symmetry value of 0.26. This is given by point A on the diagram of symmetric information sharing between clients and vendors (see Figure 5). The diagonal line on the diagram represents perfect symmetry.

In relationship B, consider a client that shares 7 of 10 potentially available types of information and a vendor that shares 7 of 9 potentially available types of information. The client value would be 0.7 and the vendor's would be 0.78, with a symmetry value of 0.9 for relationship B. This particular relationship is given by point B in Figure 5. Clearly, the relationship depicted by point B exhibits a far greater degree of symmetry in information sharing than the relationship depicted by point A. Moreover, the symmetry value for relationship B, 0.9, exceeds the symmetry value for relationship A, 0.26. Note that as points move closer to the diagonal, the symmetry value approaches 1, which would denote perfect symmetry in the information sharing practice of the client and vendor.

Measuring Degree-Symmetric Information Sharing. With a relationship's symmetry value, a client and vendor could share very little information, but still have a high symmetry value. In considering the benefits of cooperation within client–vendor relationships, the current study focuses on an examination of both the symmetry and magnitude of information sharing.

Table 5. Derivation of Degree-Symmetric Performance Variables

Derivations	Definition	Formula	Assumptions
Client or vendor value: CV_a and VV_a	Summated index of the level, l, of each item, x_i, that belongs to the set of items $\{x_1, x_2, \ldots, x_n\}$ used to measure construct, a, for the client or vendor.	$(\Sigma^n_{i=1} x_i * l_i)/(n * L)$ where $0 \leq l_i \leq L$	1. $CV_a \geq 0$ and $VV_a \geq 0$; 2. $CV_a \leq 1$ and $VV_a \leq 1$; 3. $(CV_a + VV_a) > 0$; Assumption 3 specifies a minimal level of collaboration for a dyadic relationship to be in existence. For example, in the case of the performance construct, there must be some performance attribution to the relationship by either the client or vendor. In the case of the information sharing construct, some information must be shared by either the client or vendor.
Degree value: DV_a	Summated index of the client and vendor values of the construct, a	$(CV_a + VV_a)/2$	$0 < DV_a \leq 1$
Symmetry value: SV_a	Calculated as the symmetry index of construct, a, within the client–vendor relationship.	If $CV_a \geq VV_a$, then $SV_a = VV_a/CV_a$; or If $CV_a < VV_a$, then $SV_a = CV_a/VV_a$	$0 < SV_a \leq 1$
Degree of symmetry value: DSV_a	Calculated as the index of both symmetry and value of construct, a, within the client–vendor relationship.	$(DV_a + SV_a)/2$	$0 < DSV_a \leq 1$

Table 6. Information Sharing Example

Relationship type	Amount actually shared	Total potential available
Relationship A		
Client	2	10
Vendor	7	9
Relationship B		
Client	7	10
Vendor	7	9

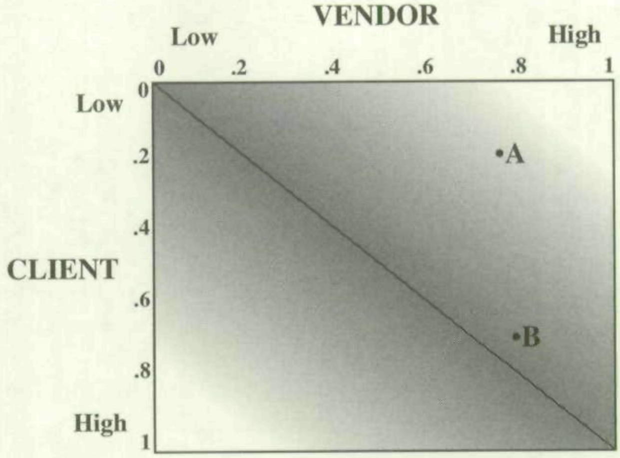


Figure 5. Symmetric Information Sharing Between Clients and Vendors

Consider relationship C, where the client shares 1 of the 3 information types with the vendor. The client value would be 0.333, or 1 divided by 3. The vendor shares 2 of the 5 types. The vendor value, therefore, would be 0.4, or 2 divided by 5. The relationship's symmetry value would be 0.85. But symmetry values alone do not account for the magnitude of the sharing within the relationship. In Figure 6, the relationship depicted by point A′ has a symmetry value of 0.8375, the relationship depicted by point B′, a symmetry value of 0.425, and the relationship depicted by point C, a symmetry value of 0.85. Moreover, relationship C has a client value of 0.34 compared to 0.67 and 0.34 for relationships A and B, respectively. For relationship C, the vendor has a value of 0.4, compared to 0.8 for both relationships A and B. These figures are detailed in Table 6. Relationship C has the lowest vendor value and ties relationship A for the lowest client value, while having the greatest symmetry value.

In an effort to account for the magnitude of sharing within the relationship, the average of the client value, vendor value, and relationship's symmetry value is used to derive the degree-symmetry value. In Table 7, the greatest degree-symmetry value is 0.7692 for relationship A, with relationships B and C at 0.5217 and 0.53, respec-

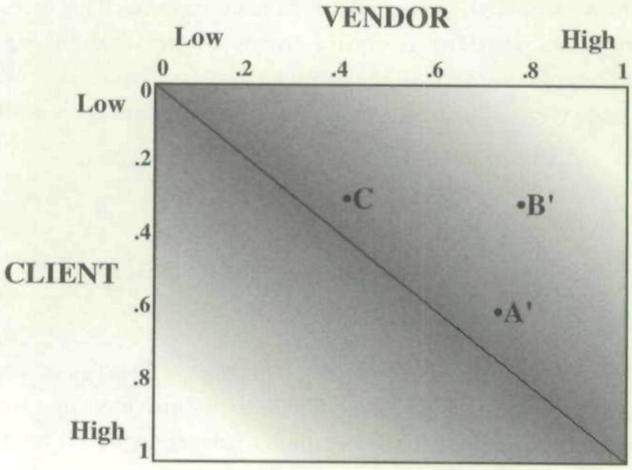


Figure 6. Multiple Relationships Symmetry Example

Table 7. Comparisons in Relationship Example

Relationship	Client sharing ratio	Vendor sharing ratio	Symmetry value	Degree-symmetric value
A	0.67	0.8	0.8375	0.7692
B	0.34	0.8	0.425	0.5217
C	0.34	0.4	0.85	0.53

tively, all on a range of 0 to 1. Whereas relationship C exhibits the highest degree of symmetry in information sharing, its degree-symmetric value (0.53) accounts for the offsetting fact that the relationship's information sharing behavior is actually lowest of the three overall.

It needs to be noted that performance measures are derived using exactly the same logic as information sharing. Any time that partners in a digital supply network are sharing information, it will affect their performance, and thus NetOP can and should also be derived from both the symmetry and extent of the performance indicators of all involved firms.

Numbered, Tiered, and Layered Perspective for Network Performance Constructs and Measures

Perspectives 1, 2, and 3 are currently being utilized in the next program phase. The subsection "Step 2: Future Research to Validate Numbered, Tiered, and Layered

Network Performance" discusses our future research approach for investigating performance measurement for complex forms of networked organizations. Conceptualization of constructs is expanded to the two additional network perspectives of tiers and layers. The section also shows current plans for a draft instrument.

Findings

Empirical Field Study: Validation of Numbered (Dyadic) Perspective NetOP

DATA WAS COLLECTED THROUGH A WEB-BASED matched survey of vendor account managers and their clients for a Fortune 500 logistics provider. In a survey strategy employed by Dyer [24], a total of 183 account managers with the vendor were contacted via e-mail by a senior executive within the marketing organization on behalf of the researcher, soliciting their participation in the study. The vendor's account managers were instructed to complete the survey on the client they had most recently been in contact with and then coordinate with that contact to facilitate completion of the client dyad of the survey. Two subsequent e-mails were sent to the account managers, reiterating the importance of their and their client's participation in the study. Some 132 account managers and 91 client contacts ultimately responded to the executive's request, for a response rate of 60 percent for the entire sample, 72 percent for the vendor's account managers, and 49 percent for the vendor's clients, which are comparable to the response rate realized by Dyer [24]. Table 8 shows the final sampling characteristics; descriptive statistics of the three latent constructs are shown in Table 9. The respondents were fairly mature professionals, with both high levels of work experience and holding relatively high positions in their organizations.

In an effort to address a potential bias in the field study, an analysis of variance between the respondents and those who responded during the fourth and final week of data collection was completed. Composite construct scores for all constructs were included in this analysis along with client organization's primary industry, primary location of the client organization by region of the country, number of employees and tenure of the client, in addition to each respondent's years of work, relationship management, and IT experience as well as gender. All in all, 37 of the 156, or 23 percent, of the total respondents completed the survey during this period of time. The results of this analysis indicate no significant difference between the two groups.

Measurement Validity of the Dyadic Degree-Symmetric NetOP Construct

Two techniques were employed to evaluate the measurement validity of the construct. First, given that even formative items can correlate with each other when the items contribute equally in making up the overall latent construct [23], we conducted a straightforward principal components factor analysis (PCA). If our performance scale items prove to be correlated, the PCA will reveal this and validities can then be further tested.

Table 8. Field Study Sample Characteristics

Variable	Category	Percent	*N*
Work experience (mean = 6.16; s.d. = 3.966)	1–5 years	41.7	182
	6–10 years	34.6	
	11–15 years	13.4	
	16–20 years	7.1	
	21–25 years	3.2	
Client's position	VP of purchasing	2.4	88
	Director/manager of operations	8.2	
	Director/manager of MIS	4.1	
	Director/manager of logistics/transportation	37.5	
	Director/manager (other)	10.5	
	Other position	21.3	
Supervisor's position	President/owner/director/ . . .	6.6	88
	VP/general manager	2.8	
	VP of finance	12.0	
	Controller	12.0	
	VP of operations	40.0	
	VP of MIS	6.5	
	VP of logistics/transportation	5.3	
	VP (other)	1.5	
	Director/manager of logistics/transportation	13.3	
Organization type	Manufacturing	14.1	88
	Banking/finance/accounting	9.0	
	Insurance	5.1	
	Real estate/legal services	12	
	Wholesale or retail	26.1	
	Government	3.8	
	Education	1.5	
	Health care	7.5	
	Communications	3.4	
	Publishing/broadcasting/ . . .	8.1	
	Computer/data processing	10.3	

Partial least squares (PLS) served as a secondary validation technique. If the initial PCA revealed standard correlational patterns among items, we reasoned that we could then look at the measurement characteristics to verify construct validity and reliability of measures. Our sample size should be sufficient for this analysis [37]. The PLS analysis in this part of our study follows exemplars such as Staples et al. [84], Loch et al. [60], and Gefen et al. [36].

PCA. The descriptive statistics on three latent constructs are shown in Table 9. The table details the range of observed values, with the possible range from 0 to 1, the mean and standard deviation for each item. Besides degree-symmetric networked organizational performance (DSP*x* and DSPT*x*), the other two constructs were degree-symmetric information sharing (DSIS*x* and DSIST*x*) and degree-symmetric dependence (DSD*x* and DSDCT*x*). Derived using the formula discussed above, the

Table 9. Field Study Construct Characteristics

Construct	Degree-symmetric item	Observed range	Mean	Standard deviation
DSIS1	Our organization shares a substantial amount of strategic information, such as production schedules, cost structures and so forth, with the vendor.	0.302–1	0.607	0.193
DSIS2	Our organization shares only the minimum transactional information, such as contact information, with the vendor, necessary to complete the transaction.	0.301–1	0.622	0.18
DSIS3	Our organization is extremely restrained with regard to sharing strategic firm information, such as production schedules, cost structures, and so forth, with the vendor.	0.301–1	0.595	0.181
DSIST1	Inventory/capacity planning.	0.238–1	0.58	0.211
DSIST2	Cost structures.	0.048–0.905	0.543	0.202
DSIST3	Margin structures.	0.048–0.905	0.531	0.198
DSIST4	Production schedules.	0.143–1	0.583	0.197
DSIST5	Marketing strategies.	0.352–1	0.614	0.192
DSP1	The client has realized substantial improvements in tangible performance outcomes, that is, things that are easily measurable or discernible.	0.302–0.905	0.642	0.159
DSP2	The client's overall economic situation has improved as a result of its relationship with the vendor.	0–1	0.65	0.140
DSP3	The client has realized substantial improvements in intangible performance outcomes, that is, things that are not easily measurable or discernible.	0.352–0.905	0.666	0.144
DSPT1	Increased productivity.	0.238–0.905	0.624	0.168
DSPT2	More timely information.	0.238–1	0.649	0.173
DSPT3	Lower operating costs.	0.352–0.905	0.644	0.141
DSPT4	Improved resource control.	0.352–0.905	0.641	0.147
DSPT5	Increased flexibility.	0–1	0.638	0.157
DSPT6	Improved production planning.	0.095–1	0.648	0.167
DSPT7	Improved asset management.	0.302–1	0.649	0.169
DSPT8	Reduced workflow.	0.31–0.905	0.632	0.165
DSDCT1	The client uses uniquely built or customized, rather than canned or generic, applications to facilitate information exchanges with the vendor.	0.31–1	0.711	0.20
DSDCT2	The applications that are used to facilitate information exchanges with the vendor can be described on a scale from generic to customized.	0.302–1	0.707	0.197
DSD1	The potential financial costs involved in switching to a new vendor are significant.	0.46–1	0.728	0.158
DSD2	The physical effort involved in switching to a new vendor would be minimal.	0.452–0.905	0.733	0.144
DSD3	Prior investments in time and money in establishing the relationship with the vendor were significant.	0.452–0.905	0.725	0.148

items should load onto the constructs as predicted, and they should not cross-load, to provide evidence of construct validity.

As Table 10 shows, the constructs load cleanly, and at high levels, on three factors exactly aligned with the three posited constructs. Therefore, this demonstrates both convergent and discriminant validity (see Campbell and Fiske [15] for a conceptual discussion of convergent and discriminant validity). Since the items are correlated at reasonable levels, it was deemed appropriate to proceed with a standard PLS analysis.

PLS Analysis. PLS item loadings were all significant at the 0.05 level, suggesting that all items contributed themselves to their respective latent constructs.

Table 11 presents intercorrelations and average variance extracted (AVE) statistics for the latent constructs. On the diagonals, AVEs explain variance by examining the ratio of the sum of the variance captured by the constructs and that captured by the measures [36].[3] Since AVEs in the diagonal cells are larger than cross-correlations in the same rows and columns, the constructs are distinct, that is, they are more closely aligned with themselves than with constructs with which they are posited to differ [36].[4] In that the AVEs here are moving toward unity and all exceed 0.50, there is additional evidence that the measures converge [28]. All in all, we believe that our instrumentation more than demonstrates adequate convergent and discriminant validity.

Table 12 shows the PLS internal consistency statistics and Cronbach's α for the measurement model. Based on commonly accepted standards [73], these results indicate that the constructs are reliably measured and, overall, are acceptable for further use by IS researchers.

Nomological Validity. Given our formulation of the two propositions positing direct effects of information sharing and dependence on networked organizational performance, we offer the following hypotheses to test nomological validity. Nomological validity assesses whether construct linkages behave in accordance with an established theoretical framework. If so, this is sufficient evidence that the constructs have themselves been properly formulated [14].

> *H1: The greater the degree-symmetric information sharing in a dyad, the greater the dyad's networked organizational performance.*

> *H2: The greater the degree-symmetric dependence in a dyad, the greater the dyad's networked organizational performance.*

PLS tested these hypotheses. As shown in Figure 7, results provide strong evidence that greater information sharing and greater dependence within a dyad yield higher dyadic performance.

Step 2: Future Research to Validate Numbered, Tiered, and Layered Network Performance

In step 2 of the program of research alluded to in this paper, a follow-up study will adopt all three network perspectives in assessing network performance. In short, the

Table 10. PCA Factor Structure

Item	Degree-symmetric item	Factor 1	Factor 2	Factor 3
DSIS1	Our organization shares a substantial amount of strategic information, such as production schedules, cost structures and so forth, with the vendor.	0.797		
DSIS2	Our organization shares only the minimum transactional information, such as contact information, with the vendor, necessary to complete the transaction.	0.778		
DSIS3	Our organization is extremely restrained with regard to sharing strategic firm information, such as production schedules, cost structures and so forth, with the vendor.	0.772		
DSIST1	Inventory/capacity planning.	0.846		
DSIST2	Cost structures.	0.804		
DSIST3	Margin structures.	0.831		
DSIST4	Production schedules.	0.833		
DSIST5	Marketing strategies.	0.830		
DSP1	The client has realized substantial improvements in tangible performance outcomes, that is, things that are easily measurable or discernable.		0.795	
DSP2	The client's overall economic situation has improved as a result of its relationship with the vendor.		0.791	
DSP3	The client has realized substantial improvements in intangible performance outcomes, that is, things that are not easily measurable or discernable.		0.802	
DSPT1	Increased productivity.		0.826	
DSPT2	More timely information.		0.786	
DSPT3	Lower operating costs.		0.804	
DSPT4	Improved resource control.		0.795	
DSPT5	Increased flexibility.		0.809	
DSPT6	Improved production planning.		0.811	
DSPT7	Improved asset management.		0.787	
DSPT8	Reduced workflow.		0.754	
DSDCT1	The client uses uniquely built or customized, rather than canned or generic, applications to facilitate information exchanges with the vendor.			0.648
DSDCT2	The applications that are used to facilitate information exchanges with the vendor can be described on a scale from generic to customized.			0.673
DSD1	The potential financial costs involved in switching to a new vendor are significant.			0.629
DSD2	The physical effort involved in switching to a new vendor would be minimal.			0.650
DSD3	Prior investments in time and money in establishing the relationship with the vendor were significant.			0.610

Table 11. Intercorrelations and AVEs of Variables

Construct	1	2	3
1. Degree-symmetric information sharing	**0.895**		
2. Degree-symmetric networked organizational performance	0.623	**0.803**	
3. Degree-symmetric dependence	0.653	0.708	**0.832**

Note: The boldface figures along the diagonal denote the AVE.

Table 12. Internal Consistency of Constructs

Construct	Number of items	PLS internal consistency	Cronbach's α
Degree-symmetric networked organizational performance	11	0.691	0.943
Degree-symmetric information sharing	8	0.817	0.939
Degree-symmetric dependence	5	0.731	0.866

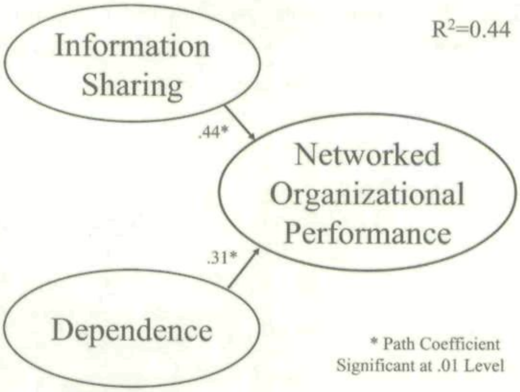


Figure 7. Nomological Validation

study will analyze data so that more complex interactions between parties can be examined.

Much of the data gathering will take place in semistructured interviews using the sampling technique of snowballing. To ensure that we are capturing the full complexity of the constructs, some of which are novel in the literature or have not been examined through field study–interview methods, there needs to be a development and validation of the interview script (or schedule). We envision free format, unstructured interviews to ensure a correct set of questions to capture the content and context of the instrumentation [85]. Taking a draft instrument to the field is the next obvious step [17, 85] in the development of construct-valid measures. This pretesting set of interviews will be followed by a pilot test of the final script.

Draft Instrumentation in Future Research

Work to date has led to an initial set of measures for the nomological network discussed earlier in this paper. Information sharing, like network performance, is subject to issues of symmetry and degree. Therefore, the *K* members of a given network can be sharing information at a certain degree-symmetric value. The degree-symmetric information construct can be assessed for each of the types of interactions shown in Figures 2 and 3. In the case of the triadic-, quadratic-, and quindratic-nodal interactions, comparisons of degree-symmetric information for a given nodal interaction can be made based on the nature of ties.

Likewise, *l* networks can demonstrate performance at different levels of symmetry and magnitude *(degree-symmetric network performance).* Objective performance measures derived from income statements and balance sheet information provide useful information about asset efficiencies and net trade cycle for a firm. Possible measures were presented in Table 3 and illustrate how the performance of various supply networks might be captured. This firm-level objective information is available from public sources such as SEC 10K reports. Firms associated with a supply network can be examined to compute degree of network performance and symmetry of network performance. Inventory turns, for example, are a very useful metric of a firm's inventory flow relative to demand, and they can be examined at the network level across a defined number of nodes, tiers, and layers, in terms of both its degree and its symmetry. Similarly, net trade cycle, a very useful metric of a firm's cash-to-cash conversion cycle, can be examined at the network level in a similar manner. In addition to objective measures derived from a firm's filings of 10K reports, interviews with managers can be used to collect information about intangibles. These measures will have to be validated for content validity before they can be further investigated, of course.

Implications

THIS RESEARCH MAKES NUMEROUS CONTRIBUTIONS from both an academic and practical standpoint. First, the research adopts the network as the primary unit of analysis, an approach taken by few studies within the IS community [18, 25], nearly all prior studies having studied serial value chains. In enhancing our understanding of firm-level activities and their subsequent value network initiatives, it is incumbent on researchers to focus on the many sides of relationships, examining clients and vendors jointly, and extending this into different tiers and layers of these relationships. This research is one of the few works within the IS community to take such a focus.

Next, this research has developed and validated a set of procedures that can be adopted in examining symmetry in dyadic relationships. Prior research has focused on gathering information from, and/or about, either firms or clients/customers. Moreover, although useful as a starting point, analysis of dyadic data to date has not taken into account symmetry in the data, which is indicative of nature of appropriation of gains and losses among network members. The procedures and derived measures developed in this work serve as a basis for the scholarly community to further analyze dyadic data and develop our understanding of value creation and value appropriation within digitally enabled networked organizations.

Thus, construct and measurement development is the major scientific result from this program of research. We further develop the novel construct of networked organizational performance from numbered, tiered, and layered perspectives. The concepts of degree and symmetry are usefully applied to all three perspectives to discover and investigate causes for variations in the nominal degree and relative symmetry of performance.

In practice, firms like Cisco, Dell, Eli Lilly, IBM, and GE can use the results to fine-tune the measurement of performance of their production and distribution networks. These firms are increasingly using outsourcing of business processes to architect their business models. Moreover, firms in virtually every industry affect, and are affected by, the resource flows across production and distribution networks. Our initial results are that firms should expand performance analysis to encompass the three network perspectives. Measurement of network properties, such as degree-symmetric information sharing, will enable development of key capabilities. Moreover, they should evaluate performance trends, in terms of both degree and symmetry, as they implement innovations targeted at enhancing network capability. This measurement should include both tangibles and intangibles. Firms whose networks are not particularly effective can also redesign them based on our findings and attempt to realize major improvements in performance.

Supply chain management solution vendors, such as UPS and SAP, can use the results to adjust their product and marketing strategies, leading to a better alignment of offerings with market requirements. They can develop product strategies based on the three network perspectives discussed here. In addition, information sharing requirements can be articulated both in terms of content and symmetry; such articulation will provide adopters a perspective on network partners with whom such network capabilities are effectively developed. As vendor companies collect data on the impact of their solutions, our initial results suggest that they are well advised to expand their analysis to the network performance level with a focus on both magnitude and symmetry of gains.

Finally, we anticipate that the results will find their way into academic curricula and courses such as supply chain management and business dynamics, given that the model advanced here is breaking new ground. These courses will be differentiated from traditional offerings in these areas because of their interdisciplinary orientation, focus on the network as the unit of analysis, and enabling role of information technology for network design and performance.

Limitations

ALL RESEARCH HAS LIMITATIONS, and this study is no exception. Data for our empirical assessment of dyadic performance measures was gathered in the context of one of the largest logistics vendor and its clients. The validity of the measures of dyadic performance should be confirmed by replicating the study and collecting data from vendors of different services and their clients. In addition, replication studies that collect data from small and mid-sized vendors and their clients will enable us to assess the external generalizability of the measures develop here across dyads associated with different-sized vendor firms.

A program of research using varying measures at different nodal interactions is underway and, therefore, this basic nomology has been empirically tested only in dyadic interactions to date. Hopefully, other researchers will also take up the call to push this work on digitally enabled networked organizations forward and gather data for varying network configurations.

Whereas the degree-symmetric measures for NetOP, information sharing, and dependence produced good measurement properties with dyadic data, we cannot know for certain that the same validities will hold across triadic-, quadratic-, quindratic-nodal, and so on interactions in a network of firms. It may be that the addition of firms to the mixture destabilizes the symmetry measures, or even possibly the degree measures. It may be necessary to reformulate the construct when this data is available and an assortment of networked organizational configurations can be tested.

Studying digitally enabled networked organizations is a difficult process in that it involves the cooperation of a large number of firms, and the commitment of these firms to the goals of the research. We encourage other researchers to make these contacts, and to use our instrumentation, where appropriate. The initial empirical testing and conceptualization of NetOP seems to be robust enough that significant new advances in this domain can now take place.

Conclusion

Measuring performance at the networked organizational level is critical for learning how supply networks operate and how they impact businesses. We know that variability in procurement processes can lead to huge over- and understocks. Each of these situations has momentous ramifications for the entire supply network and can decrement performance. The research discussed here offers a way to gather crucial information about how partners work together in sharing strategic information, about which antecedents have downstream effects, and about how performance across an entire network can be measured and thereby improved.

Notes

1. This is one of the arguments used in the productivity paradox.

2. Performance can be elevated to a social level where, in the United States, economic performance is regularly measured and reported as gross domestic product.

3. AVE is calculated as $[(\Sigma\lambda_i^2)/((\Sigma\lambda_i^2) + (\Sigma(1 - \lambda_i^2))]$.

4. Diagonal entries are the AVE, or the square root of the variance shared between the constructs and their measures. Off-diagonals are correlations between constructs. Diagonals should be larger than any other corresponding row or column entry in order to support the case for discriminant validity.

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