Organization Structure from a Loose Coupling Perspective: A Multidimensional Approach

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ABSTRACT

Organizational theories frequently rely on notions of sharing and dependence among organizational participants, but researchers usually focus on characteristics of the actors themselves instead of the relational patterns among the actors. Loose coupling is one conceptual tool that emphasizes relational patterns. Loose coupling, however, is an abstract metaphor that is simultaneously fertile and ambiguous. This paper develops a rigorous and comprehensive framework that sharpens the theoretical contributions of loose coupling to our understanding of structural relationships. Characteristics of loose coupling capture some important and underexplored features of multidimensional fit and interdependence in organizations. The proposed framework clarifies these theoretical contributions of loose coupling with concepts and equations modified from network analysis. Testable hypotheses are proposed with respect to three key independent variables that may affect patterns of coupling: organization strategy, technology, and environmental turbulence. Additional hypotheses are advanced with respect to the use of the multidimensional approach to loose coupling in studying new organizational forms. Initial psychometric and empirical evidence are presented.


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INTRODUCTION

Organizational phenomena such as institutionalization, resource dependence, and social structure are frequently defined in terms of systematic patterns of interaction among organizational elements (Daft, 1997). Previous approaches to conceptualizing and measuring structure, however, have been primarily static, have shown low convergent and discriminant validity (Pennings, 1973), have focused on organizational elements themselves rather than on the relationships among the elements (Weick, 1985), and have modeled only two or three variable interactions rather than capturing the full multidimensional patterns of fit (Doty, Glick, & Huber, 1993).

One provocative theoretical approach that explicitly focuses on the relationships or interaction among organizational elements is loose coupling (Weick, 1976). It encourages researchers to consider simultaneously the interdependence and indeterminacy in the pattern of interactions among organizational elements (Orton & Weick, 1990). Loose coupling, however, is a metaphor that "has a rare combination of face validity, metaphorical salience, and cutting-edge mysticism, all of which encourage researchers to adopt the concept but do not help them to examine its underlying structure, themes, and implications" (Orton & Weick, p. 203). This metaphor needs to open up to the probing of researchers, or else it may become isolated from empirical disproof (McPhee, 1993; Spender & Grinyer, 1996).

Loose coupling should be explored for several reasons. First, its relational approach to organizational analysis captures the essence of organizations as systematic patterns of interaction (Weick, 1985). Second, more researchers are recognizing the importance of loosely coupled, namely, weakly related and fairly independent elements in a variety of areas: functional and resource dependence (Beekun & Ginn, 1993), control (Daft & Weick, 1984), culture and structure (Kerwood, 1995), strategic flexibility (Sanchez, 1997), high reliability organizations (Snook, 2000), risk mitigation (Grabowski & Roberts, 1998), and education (Logan, Ellett, & Licata, 1993). Finally, the phrase loose coupling implies a tension between determinacy (coupling) and indeterminacy (looseness). The resultant paradoxical nature of "loosely coupled" organizations makes imperative the development of novel, yet less ambiguous definitions of loose coupling.

One conceptual approach that can capture the rich dialectical nature of the loose coupling metaphor is network analysis. Network analysis provides a mathematical language for modeling patterns of relationships among actors (Tsai & Goshal, 1998). Translating the verbal arguments of loose coupling into a mathematical language can help to clarify them. Network analysis also furnishes a natural bridge across levels of analysis since the elements in a network can be individuals, workunits, or organizations.

Our main thesis is that a more formal explication of loose coupling based on the mathematical foundation of network analysis will facilitate the advancement of this concept beyond a literary metaphor. We argue in favor of developing loose coupling as a scientific rather than a literary metaphor. Literary metaphors emphasize evocation and sensorial vividness, whereas scientific metaphors stress prediction and connotative descriptions (Gentner, 1982).
This paper focuses on three major contributions. First, coupling is described in terms of systematic patterns of relationships among organizational elements located within multiple domains and connected by identifiable mechanisms. These coupling relationships are also depicted as varying along theoretically relevant dimensions. Second, the components of coupling are translated into network analysis terms to clarify and operationalize the theoretical definitions of loose coupling. Third, this multidimensional approach is used to advance coupling research, and partial empirical evidence is provided to validate the framework proposed here.

THE CONCEPT OF LOOSE COUPLING

Coupling is usually defined as the relationship among elements or variables, while loose coupling refers to a general characteristic of these relationships—the degree to which the relationships are loose rather than tight. A primary strength of loose coupling is its relational focus. Coupling is defined as the relationship between any “A” and any “B” (Weick, 1982), and varies in strength along a continuum from loose to tight. Thus, any development of loose coupling should capitalize on its focus on relations.

The plethora of definitions of loose coupling incorporates a multidomain, multidimensional approach to the organizing process. Organizational participants are linked simultaneously by bureaucratic and cultural ties, by functional and resource interdependencies, by vertical and horizontal linkages, etc. The multidimensional nature of loose coupling also implies that actors may be coupled both loosely and tightly at the same time. For example, two actors may be tightly coupled because of many common interests (Beekun & Ginn, 1993), but loosely coupled because of infrequent interaction (Snook, 2000). Unless prescriptive statements identify precisely which dimensions should be loose or tight, managers may implement coupling inappropriately.

A MULTIDIMENSIONAL FRAMEWORK

To move beyond the literary metaphor, a multidimensional framework is proposed that maintains the relational focus of loose coupling while formally explicating characteristics of structural relationships in the context of the coupling. This framework relies on three components mentioned in the coupling literature (Firestone, 1985; Beekun & Ginn, 1993; Grabowski & Roberts, 1998): elements, dimensions, and mechanisms. To provide a more complete picture of coupling, one additional component, domain, is introduced based on suggestions by several theorists (Perrow, 1984; Orton & Weick, 1990; Kerwood, 1995). This multidimensional model is described below and presented in Table 1.

Coupling Elements

Coupling elements refer to “anythings that may be tied together” (Weick, 1976, p. 5), and have a broad range: performance indicators may be coupled with decisions or goals (Johnsen, 1999), actors coupled with actors (Tsai & Goshal, 1998), sub-units coupled with sub-units (Snook, 2000), and systems coupled with systems (Mayer & Whittington, 1999).
Table 1: Constitutive and operational definitions for a multidimensional framework of loose coupling.

<table>
<thead>
<tr>
<th>Coupling Components</th>
<th>Constitutive Definition</th>
<th>Operational Definition Based on Network Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupling elements</td>
<td>“Anythings that may be tied together” (Weick, 1976, p. 5).</td>
<td>Any actor, $i$, who sends or initiates a relationship, $z$, to another actor, $j$. This relationship is then symbolized as the relation, $z_{ij}$.</td>
</tr>
<tr>
<td>Coupling domains</td>
<td>The content area of the relationship between coupling elements, e.g., communication, workflow, resource exchange, etc.</td>
<td>The content of network relations such as communication and authority. A network contains at least one content, but may contain any number of defined contents.</td>
</tr>
<tr>
<td>Coupling dimensions:</td>
<td>The quality of the interaction among coupling elements.</td>
<td>Each relationship is characterized by the relative strength of the network linkage. Thus, $z_{ij}$ can represent the frequency with which person $i$ seeks technical advice ($k$) from person $j$.</td>
</tr>
<tr>
<td>• Strength</td>
<td>Characterized by several subdimensions that capture a different subdimension of coupling uniquely, e.g., frequency and intensity of interaction.</td>
<td>Each relationship is characterized by the relative strength of the network linkage. Thus, $z_{ij}$ can represent the frequency with which person $i$ seeks technical advice ($k$) from person $j$.</td>
</tr>
<tr>
<td>• Directness</td>
<td>The number of linkages between any two actors.</td>
<td>Assesses the minimum of steps between actor $i$ and actor $j$ in domain $k$.</td>
</tr>
<tr>
<td>• Consistency</td>
<td>The diversity of the reactions of coupling elements to similar external stimuli. The more consistently two actors interact, the more tightly coupled they are.</td>
<td>Consistency is high when relationships in any domain, $k$, are not substitutable for, or confused with, relationships with any other domain, $h$.</td>
</tr>
<tr>
<td>• Dependence</td>
<td>The relative magnitude of an exchange and the lack of substitutes for the exchange among coupling elements (Pfeffer &amp; Salancik, 1978)</td>
<td>Overall dependence is a multiplicative function of the relative magnitude of an exchange (as a proportion of inputs and outputs in the exchange), and of the degree to which actor $i$ lacks substitutes for actor $j$'s inputs and/or outputs.</td>
</tr>
<tr>
<td>Coupling mechanisms:</td>
<td>The practices or processes that enable elements to function together.</td>
<td>Similarity of patterns of interaction between organizational members and external constituencies.</td>
</tr>
<tr>
<td>• Differentiation</td>
<td>The heterogeneity of actors' positions in the workflow and task-related communication patterns.</td>
<td>The degree to which organizational members are directly coupled to each other through strong ties in multiple domains.</td>
</tr>
<tr>
<td>• Integration</td>
<td>The process of coordinating the efforts of organizational actors towards a unified goal.</td>
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</table>
Coupling Domains

A coupling domain describes the content area of the relationship between coupling elements. For example, two subunits may exchange task-related information (task-related communication domain), or may work together on the assembly line (workflow domain). In general, researchers have discussed coupling relationships within the following domains: task-related communication domain involving work-related information (Grabowski & Roberts, 1998); non-task-related communication domain involving communication not related to work (Covaleski & Dirsmith, 1983); workflow domain entailing task-related activities such as production (Ibarra, 1993); bureaucratic domain involving support (non-production-related) tasks (Firestone & Wilson, 1985; Kerwood, 1995); resource exchange domain pertaining to the exchange of resources (Kerwood; Spender & Grinyer, 1995); structuring domain including design changes and new organizational forms (Sanchez, 1997; Westphal & Zajac, 1998); and social domain pertaining to informal, social communication, and socialization (Covaleski & Dirsmith; Kerwood).

The above coupling domains can be placed on a continuum ranging from formal structural to informal structural depending upon the content of the activity linking the coupling elements. Structure typically refers to “the sum total of the ways in which [an organization] divides its labor into distinct tasks and then achieves coordination among them” (Mintzberg, 1993, p. 2). Formal structural domains comprise prescribed, consciously planned activities, whereas informal domains include activities that are spontaneous and unplanned.

Two additional differences among the possible contents of relations can be introduced to supplement the domains discussed above: actual versus perceived and temporal distinctions. Loose coupling can be applied to both the actual coupling between elements as well as the perception of that coupling. For example, the perception of tight coupling between two tasks in the production process may be based on the actual logical sequencing of the tasks. The presumption of logic (Weick, 1982) in the perceptual domain, however, may create a self-fulfilling prophecy of tight coupling in the domain of the actual workflow.

Temporal distinctions in the coupling domains are also important. Loose coupling is a dynamic process (Andersson, 1992; Snook, 2000). Elements that were loosely coupled previously may become tightly coupled today. Further, when some coupling relations are viewed within a short time horizon, they may appear tightly (loosely) coupled, but in the long run they may be loosely (tightly) coupled. Thus, coupling’s temporal aspect must be tracked when appropriate.

Coupling Dimensions

A coupling dimension characterizes the quality of the relationship among coupling elements (Weick, 1982). Dimensions of loose coupling often mentioned in the literature are: strength, directness, consistency, and dependence.

Strength

The verb “to couple” has been modified by several adverbs that describe the strength of coupling, including: frequently, intensely, probably, and negligibly (Weick, 1982; Grabowski & Roberts, 1998). Each of these adverbs captures a
unique subdimension of the strength of coupling. For example, two people are loosely coupled if they have infrequent social conversations, but may also be tightly coupled if those talks are intense and last a long time.

**Directness**
Loosely coupled elements are less directly related to each other (Weick, 1982; Grabowski & Roberts, 1998). Organizational participants are loosely coupled if they communicate together through several levels of hierarchy rather than directly. Noise may permeate a communication process that includes intermediaries, and may thus weaken the linkages.

**Consistency**
The more diverse the reactions of coupling elements to a similar external stimulus, the more loosely coupled these elements are (Orton & Weick, 1990). Generally, loosely coupled manufacturing plants can adapt in a variety of ways (Perrow, 1984). They can substitute plastic for metal, install robotic devices, etc. By contrast, tightly coupled systems permit only one production method and almost no substitution of raw materials. In contrast to other dimensions of coupling, consistency is based on comparisons of relations across domains for a single sender or receiver. When relations in one domain are easily substituted for relations in another domain, consistency across domains is lower, and coupling is looser.

**Dependence**
Loosely coupled elements are relatively autonomous of one another (Weick, 1976). The degree of dependence among elements is based on both the relative magnitude of the exchange and the lack of substitutes for the exchange (Pfeffer & Salancik, 1978). The relative magnitude of an exchange can be gauged by "the proportion of total inputs or the proportion of total outputs accounted for by the exchange" (Pfeffer & Salancik, p. 46). For example, a franchised restaurant obtaining its inputs from one source will be more dependent than a store requiring inputs from multiple sources. The lack of substitutes for a resource also increases dependence on the supplier of that resource and decreases strategic flexibility (Sanchez, 1997).

Many dimensions of coupling are expected to be related to each other. Weick (1982) suggested that strength, directness, consistency, and dependence are positively correlated. Looser relationships among coupling elements are indicated by lower strength, lower directness, lower consistency, and lower dependence. The magnitude of the correlations among these dimensions should be assessed empirically across elements and domains.

**Coupling Mechanisms**
Coupling mechanisms describe the practices or processes that enable elements to function together. Four characteristics of coupling mechanisms are apparent. First, coupling mechanisms pertain to a larger unit of analysis than the dyadic coupling relationship. For example, centralization, a coupling mechanism (Firestone, 1985; Logan et al., 1993), characterizes a system (workunit or organization). Coupling
dimensions characterize dyadic relationships, while coupling mechanisms describe the overall pattern of relationships among a set of elements.

A second feature of coupling mechanisms is that they connote predictability (Firestone & Wilson, 1985) by introducing a framework whereby behavior becomes coherent. If a coupling mechanism is in place, “A” has some assurance that “B” will behave as expected. Third, a coupling mechanism connects coupling elements into identifiable clusters on the basis of some common process.

Structural coupling mechanisms represent the formal arrangements within an organization that allows it to function (Logan et al., 1993). These mechanisms are found in formal, task-related, namely structural domains and can be modified only through formal decisions. Examples of structural coupling mechanisms are: the hierarchy of authority (Logan et al., 1993; Snook, 2000), rules (Darden, Deconink, Babin, & Griffin, 1991), and differentiation and integration (Lawrence & Lorsch, 1967; Hitt, Hoskisson, & Nixon, 1993). Because of their inclusion in the application section of this paper, the latter two mechanisms are now discussed in detail.

**Differentiation and integration**

Lawrence and Lorsch (1967, pp. 3-4) defined differentiation as “the state of segmentation of the organizational system into subsystems, each of which tends to develop particular attributes in relation to the requirements posed by its relevant external environment.” By contrast, they defined integration as “the process of achieving unity of effort among the various subsystems in the accomplishment of the organization’s task” (Lawrence & Lorsch, p. 34). Hence, differentiation refers to the heterogeneity of actors’ positions in the workflow and task-related communication patterns. If participants at the same organizational level occupy equivalent or substitutable positions in the work and communication flows, then the organization will be less horizontally differentiated. Alternatively, larger differences among the participants’ positions reflect greater horizontal differentiation. As Hitt et al. (1993) indicated, high functional differentiation may be compensated by coupling through shared values and focused attention.

Using the above mechanisms, the differences between rational systems theorists and the loose coupling perspective can be highlighted. Under conditions of high environmental turbulence, Lawrence and Lorsch (1967) favored systems exhibiting high differentiation-high integration. Conversely, Perrow (1984) and Weick (1982) valued a mix of high differentiation-low integration because short-term adaptation can then be traded off for longer term adaptability.

**Integrating the Four Components of Coupling**

To illustrate how the multidimensional approach to loose coupling works, an integrative example will be presented depicting the fictional interaction among several departments: finance, production, personnel, marketing, and research and development. The departments represent coupling elements. The company where these departments are located stresses internal efficiency. The finance department closely monitors all financial decisions that production, personnel, and marketing make (high strength in the task-related communication domain). By contrast, research and development oversees the external grant money from which it funds its
projects. Few of its financial decisions are monitored (low strength and directness in the task-related communication and resource exchange domains), and it is loosely coupled with the finance department. At the same time, because production wants to minimize costs and marketing aims to offer a broad range of products, these two departments interact more frequently and directly with each other (high on the strength and directness coupling dimensions in the task-related communication and workflow domains) than with another department such as personnel.

**COUPLING EXPRESSED IN TERMS OF RELATIONSHIPS IN A NETWORK**

The above coupling framework focuses on the notion of exchanges among actors and provides an appropriate context for demonstrating how structural relationships can be clarified through the use of network analysis. Although recent coupling research (Kerwood, 1995; Hadjikhani & Seyed-Mohammed, 1997) has linked loose coupling to networks, organization researchers need to formalize the rich verbal arguments of loose coupling into a mathematical language so as to increase clarity and precision in the arguments. Accordingly, we now develop the second contribution of the paper and translate the four components of coupling into network analysis terms to clarify and measure the construct.

**What Is Network Analysis?**

A network is a set of relationships of different magnitudes among a defined set of persons or other elements for any defined set of contents (Burt & Schott, 1989). Network analysis is a set of mathematical and statistical techniques for describing and analyzing network data. Various measures can be used to characterize a network in terms of the overall pattern of relationships; an individual’s position relative to the whole organization; an individual’s position relative to other individuals; the pattern of relationships among groups of individuals; the linkages among clusters of organizations, etc.

**Coupling Elements**

Coupling elements are represented as actors in a network. The actors can be any structural elements such as people, departments, or organizations. The actors can be any other things that may be tied together, such as attitudes, actions, elements in a cause map (Burt & Schott, 1989), organizations (Beekun & Ginn, 1993), or systems (Grabowski & Roberts, 1998). This latitude in defining actors implies that network analysis is sufficiently general to capture the variations of loose coupling elements. In network terminology, a relationship between two coupling elements is symbolized as the relationship, $z_{ij}$, from actor, $i$, who initiates a relationship, $z$, with another actor, $j$.

**Coupling Domains**

Coupling domains are represented as the content of network relationships such as communication, workflow, and authority. A network contains at least one content, but may contain any number of defined contents. Symbolically, network analysis
distinguishes among coupling domains by subscripting any relationship, \( z_{ij} \), with a third character, \( k \), to denote the content of the relationship, \( z_{ijk} \).

**Coupling Dimensions**

**Strength**

The stronger the linkages between elements, the tighter is the coupling (Weick, 1982; Snook, 2000). The strength of a coupling relationship can be described along several subdimensions such as frequency, intensity, and probability. Similarly, in network analysis, each relationship is characterized by the relative strength of the linkage. Thus, \( z_{ijk} \) can represent the frequency with which person \( i \) seeks technical advice (\( k \)) from person \( j \), or the probability that person \( i \) might initiate a social conversation (\( k \)) with person \( j \) during a typical day.

**Directness**

The more direct the linkages between elements, the tighter is the coupling (Weick, 1982; Snook, 2000). If two actors are not linked directly and must communicate through a long series of intermediaries, they are loosely coupled. Shorter path distances indicate tighter coupling. Accordingly, the directness measure, \( \text{DIR}_{ijk} \), is calculated as the multiplicative inverse of the path distance between any two actors in a coupling domain.

\[
\text{DIR}_{ijk} = \frac{1}{a_{ijk}},
\]

where \( a_{ijk} \) is the minimum number of steps from actor \( i \) to actor \( j \) in domain \( k \). If there is no path from actor \( i \) to actor \( j \) in domain \( k \), then \( \text{DIR}_{ijk} \) should be set to zero.

Burt (1982, equation 2.4) presented a simple equation for calculating the minimum number of steps between actors that is based on raising a matrix of relations to successive powers. In parallel with the conceptual definition of directness, this measure is not sensitive to variations in the strength or intensity of the relationships in the path from actor \( i \) to actor \( j \). The measure is only sensitive to the presence or absence of a relationship and the directionality of relations.

**Consistency**

Consistency is high when relationships in one domain are not substitutable for, or confused with, relationships in another domain. Tightly coupled actors are less likely to substitute relationships in one domain for relationships in another domain (Perrow, 1984). Perrow suggested that a measure of consistency should focus on the degree to which the sequences in a system are invariant and cannot be changed or substituted for each other. Network analysis researchers gauge invariance and lack of substitutability by the presence or absence of confusion between domains (Burt & Schott, 1989). Burt and Schott suggested that interactions occupying "the same points in [semantic] space are substitutable in respondent descriptions of his [her] relationships" (p. 196).
The consistency dimension of coupling involves a comparison across multiple domains, \( g, h, \) and \( k \), across all targets, \( j \), with whom actor \( i \) reports relationships. Let \( c_{ik} \) be the probability that an actor perceives a relationship between himself and any other actors, \( j \), in the \( k^{th} \) domain rather than other domains, then,

\[
c_{ik} = \frac{\sum_j a_{ijk}}{\sum_k \sum_j a_{ijk}},
\]

where \( a_{ijk} \) is 1 if actor \( i \) reports a relationship with actor \( j \) in domain \( k \) (namely, \( z_{ijk} > 0 \)), and is 0 otherwise. Further, let \( c_{ikg} \) be the conditional probability that interaction in domain \( g \) will be reported in a coupling relationship that already involves a relationship in domain \( k \). Then,

\[
c_{ikg} = \frac{\sum_j (a_{ijk} \cdot a_{ijg})}{\sum_j a_{ijk}},
\]

where \( a_{ijg} \) is 1 if actor \( i \) reports a relationship with actor \( j \) in domain \( g \) (namely, \( z_{ijg} > 0 \)), and is 0 otherwise.

If the domains are measured with different metrics, then \( a_{ijk} \) and \( a_{ijg} \) must be adjusted to a common scale and unit weighting prior to using these two equations. Finally, consistency across coupling domains, \( CON_{ikg} \), can be defined similarly to Burt and Schott's (1989) measure of nonsubstitutability across patterns of confusion relations:

\[
CON_{ikg} = \sqrt{(C_{ikk} - C_{igg})^2 + (C_{ikg} - C_{igk})^2 + \sum_h ((C_{ikh} - C_{igh})^2 + (C_{ihk} - C_{ihg})^2)},
\]

where \( c_{ikh} \) is the conditional probability that interaction in domain \( h \) will be reported in a coupling relationship that already involves a relationship in domain \( k \).

The rationale for this measure of consistency across coupling domains parallels Burt's (1983) and Burt and Schott's (1989) explanation that interactions in different domains, \( k \) and \( g \), are substitutable to the extent that: (1) actor \( i \) reports interactions in both domains with equal frequencies (namely, \( c_{ikk} = c_{igg} \)); (2) actor \( i \) is as likely to substitute interactions in domain \( k \) for \( g \) as he or she is likely to substitute interactions in domain \( g \) for \( k \) (namely, \( c_{ikg} = c_{igk} \)); and (3) interactions in domains \( g \) and \( k \) are equally likely to be substituted for interactions in all other
domains by actor \( i \) (namely, \( c_{ik} = c_{ik} \) and \( c_{ik} = c_{ik} \)). In terms of the consistency dimension, an individual is tightly coupled across two domains to the extent that he or she consistently uses different patterns of relationships across the domains.

**Dependence**

Loosely coupled elements are relatively independent of each other (Pfeffer & Salancik, 1978; Snook, 2000). In assessing financial independence, Rubin (1979) focused only on the magnitude of the exchange. She looked at the ratio of revenue received to revenue generated. However, Pfeffer and Salancik suggested that dependence is a multiplicative function of two subdimensions: the relative magnitude of an exchange and the lack of substitutes for the exchange. The relative magnitude of the exchange, \( DEP(RM)_{ij} \) between elements \( i \) and \( j \) is based on \( i \)'s proportion of inputs and outputs in exchanges with \( j \) relative to \( i \)'s exchanges with others:

\[
DEP(RM)_{ij} = \frac{\sum_k \left( \frac{z_{ijk}}{\sum_j z_{ijk}} + \frac{z_{ijk}}{\sum_j z_{ijk}} \right)}{2k}
\]

To the extent that actor \( i \) lacks substitutes for actor \( j \)'s inputs and outputs, dependence is high. The less substitutable a particular input or outlet, the more others will depend on it. The lack of substitutes subdimension of dependence, \( DEP(LS)_{ij} \), partly resembles the consistency dimension, \( CON_{ik} \). The lack of substitutes measure, however, replaces the multiple domains in the three previous equations (namely, \( c_{ik} \), \( CON_{ik} \), and \( DEP(RM)_{ij} \)) with multiple receivers and sources, \( j \), \( q \), and \( r \). Thus, \( s_{ij} \) is the probability that \( i \) sends resources to \( j \) rather than other actors,

\[
s_{ij} = \frac{\sum_k a_{ijk}}{\sum_j \sum_k a_{ijk}}
\]

where \( a_{ijk} \) is 0 if \( z_{ijk} = 0 \), and is 1 otherwise.

The probability that actor \( i \) receives resources from actor \( j \) across all domains, \( s_{ji} \), is then the same as the equation above, except that \( a_{ijk} \) is replaced with \( a_{jik} \). Further, \( s_{iq} \) is the conditional probability that actor \( i \) sends resources to actor \( q \) in a domain where \( i \) already sends resources to \( j \).

\[
s_{ijq} = \frac{\sum_k (a_{ijk} \cdot a_{iqk})}{\sum_k a_{ijk}}
\]
where $a_{ijk}$ is 0 if $z_{ijk} = 0$, and is 1 otherwise.

Again, the corresponding equation for inputs (rather than outputs) is a simple replacement of $a_{ijk}$ and $a_{ijk}$ with $a_{ijk}$ and $a_{ijk}$, respectively, in the preceding equation for $s_{ijq}$. This change yields a measure of $s_{jiq}$, the conditional probability that actor $i$ receives resources from actor $q$ in a domain where actor $i$ already receives resources from actor $j$. Thus, the lack of substitutes across receivers and sources, $DEP(LS)_{ij}$, is

$$DEP(LS)_{ij} = \frac{1}{\sum_{q} \sum_{r} \left( (s_{ijr} - s_{ijq})^2 + \sum_{r} ((s_{irj} - s_{irq})^2 + (s_{irj} - s_{irq})^2) \right)} \left( \frac{1}{2Q} \right).$$

(8)

Thus, following the multiplicative combination of dependence and substitutability suggested by Pfeffer and Salancik (1978), the measure of overall dependence of actor $i$ on actor $j$ is:

$$DEP_{ij} = DEP(RM)_{ij} + DEP(LS)_{ij}.$$ 

(9)

Hence, the network measure of dependence, $DEP_{ij}$, takes into account both the relative magnitude and lack of substitutability subdimensions to capture the tightness of coupling of actor $i$ to actor $j$. Again, each domain is given unit weighting, unless previously adjusted.

**Coupling Mechanisms**

Coupling mechanisms represent the macro-level practices and processes that hold coupling elements together (Firestone, 1985; Logan et al., 1993). While coupling dimensions characterize relationships between two actors, coupling mechanisms describe the pattern of relationships among multiple actors in the whole system or network subgroup. Most coupling mechanisms involve complex descriptions of relational patterns that do not have any direct analogs at the individual or dyadic levels of analysis. Some coupling mechanisms such as hierarchy of authority, however, do have indirect analogs at the dyadic level. Thus, it is possible to describe individual $i$ as being tightly or loosely supervised in an organization with a strong hierarchy of authority. For example, Firestone (1985) and Logan et al. (1993) assessed coupling through structural mechanisms by way of individual level outcomes such as more frequent task-related communication between a supervisor
and subordinate. However, other coupling mechanisms may be more appropriately measured at a macro level of analysis; for example, differentiation, integration, centralization, etc.

**Differentiation**

Horizontal differentiation is the heterogeneity of actors’ relational positions in task-related domains. Differentiation is high when organizational members have dissimilar patterns of interaction with each other and with external constituencies. At the extreme, each member occupies a unique structural position in his or her relationships with other organizational members and constituencies. Thus, differentiation, $DIF_{_..}$, is

$$DIF_{..} = \frac{\sum \sum (\sum (z_{iqk} - z_{jkq})^2 + (z_{qik} - z_{qjk})^2)}{N(N-1)}.$$  (10)

Here, $z_{iqk}$ is the strength of the relationship from organizational member $i$ to actor $q$ in task-related domain $k$; $q$ is either an organizational member or organizational constituency; $j$ is an organizational member, where $j \neq i$; and $N$ is the number of organizational members. Note that the numerator in the measure of $DIF_{..}$ is similar to the Euclidean distance measure employed in the network analysis formula for structural equivalence (Burt, 1982).

**Integration**

Integration is defined as the coordination of efforts among differentiated subunits in order to accomplish the organization’s task. Integration can be achieved through any of the structural coupling domains except for the flow of work. When organizational members are more directly coupled to each other through strong ties in multiple domains, an organization is more highly integrated. More specifically, integration, $INT_{..}$, is defined as:

$$INT_{..} = \sum \sum \sum (DIR_{ijk} \ast \text{MAX} \ g_{ijk}) \ast \text{MAX}_{ij} z_{ijk} \ast N(N-1)K.$$  (11)

$DIR_{ijk}$ is directness, as defined above; $g_{ijk}$ is the average strength of the relationships, $z_{ijk}$, on the shortest path from $i$ to $j$ in domain $k$ (in network terminology, $g_{ijk}$ is the average $z_{ijk}$ on the geodesic from $i$ to $j$ in domain $k$); $\text{MAX} \ g_{ijk}$ is the maximum value of $g_{ijk}$ when there are multiple, equally short geodesics; and $\text{MAX}_{ij} z_{ijk}$ is the maximum strength of relationships in domain $k$ for any $i$ and $j$, and $i \neq j$. 
APPLICATION OF THE MULTIDIMENSIONAL APPROACH

As indicated by Spender and Grinyer (1996, p. 8), loose coupling "has no predictive value in its present form." To address this potential lacuna, the potential utility of the multidimensional approach to loose coupling is illustrated in the context of resource dependence, strategy typologies, technology-structure relationships, and new organizational forms.

Enriching Resource Dependence with Loose Coupling

Both loose coupling and resource dependence (Beekun & Ginn, 1993) suggest that tighter coupling is desirable when immediate action is needed. Resource dependence theorists (Pfeffer & Salancik, 1978) have traditionally hypothesized that external environmental linkages are necessary for organizations to procure the inputs they need. However, they have also recognized that when "everything is connected to everything else, it is difficult to change anything" (p. 69). By contrast, loose coupling theorists assert that under conditions of environmental uncertainty (Perrow, 1984), organizations may either loosen or break their linkages with external "others." For example, Perrow (1984) suggested that some loosely coupled subsystems are desirable in high-risk systems such as nuclear power plants. Should an accident take place, these subsystems would seal off sensitive areas.

Unlike resource dependence, the multidimensional approach to coupling does not assume that the process of loosening or tightening relationships is homogeneous across coupling domains. In response to environmental turbulence, an organization may tighten interorganizational linkages within some domains, but loosen its bonds within others. For example, although a hospital may seek money from a creditor, it may impede the flow of information about its internal well-being to the same creditor. In this case, tighter interorganizational relationships exist within the resource exchange domain, but looser connections may prevail within the information domain.

Considering the impact of environmental turbulence and the variation in the content of coupling domains, Beekun and Ginn (1993) hypothesized that:

H1: The pattern of coupling between an organization and other organizational actors will be a function of the level of environmental turbulence and the type of coupling domain.

This hypothesis is more encompassing and precise than the interorganizational linkage hypothesis advanced by resource dependence researchers and has received preliminary empirical support. In Beekun and Ginn's study of acute care hospitals in two Northeastern states, 58 chief executive officers indicated that patterns of both loose and tight interorganizational coupling varied significantly within the resource exchange and information domains as a function of increasing environmental turbulence ($F_{1,46} = 6.08, p < .05$).

Extending Strategy Typologies with the Multidimensional Approach to Loose Coupling

The resource dependence perspective assumes that an organization has a choice in the way it interacts with the external environment (Pfeffer & Salancik, 1978). Thus,
a firm’s strategy may affect the creation and patterning of interorganizational linkages. The multidimensional framework of loose coupling can extend strategy typologies with a more explicit consideration of interorganizational coupling.

Strategy typologies posit that organizational performance will vary as a function of the internal congruence among the strategy, structure, and context of the organization. The fit among strategy, structure, and contextual elements proposed by Miles and Snow’s (1978) typology is strongly correlated with organizational performance (Doty et al., 1993). Although the Miles and Snow typology focuses on intraorganizational linkages, a natural extension of this configurational theory is the incorporation of interorganizational linkages consistent with each of the strategy types. The need for environmental alignment implicit in the adaptive cycle suggests that interorganizational linkages should be consistent with the strategy type that is approximated by the organization. This extension reflects the use of strategy to maintain or establish control through the vast array of interorganizational linkage processes available to organizations (Blair & Boal, 1991). Hence, when managing its external resource dependencies, the resource and information requirements implied by an organization’s strategy gestalt (Young, Beekun, & Ginn, 1992) are likely to determine which connections with external actors it will loosen and/or tighten.

Relying on Miles and Snow’s (1978) strategy types, Shortell, Morrison, and Friedman (1990) suggested that reactor and defender ideal types take a passive attitude towards external events (Young et al., 1992). The defender type is more internally focused on acute inpatient care and efficiency. Thus, firms similar to the defender type are expected to have fewer exchanges with other organizations (lower frequency), but these exchanges are likely to be more invariant (higher consistency). By contrast, the reactor type lacks focus; it does not attend to anything unless forced to. Consequently, firms approximating the reactor type are expected to have fewer and less predictable external transactions (lower frequency and lower consistency).

Unlike the defender and reactor ideal types, the prospector and analyzer ideal types are opportunists (Miles & Snow, 1978). Prospectors engage in much broader scanning of their environment (Young et al., 1992). Organizations that are similar to the prospector type can be expected to direct more initiatives towards other organizations (high frequency). Prospectors’ external transactions are very unpredictable because of their desire to jump at any opportunity (low consistency). Analyzers display a follow-the-leader attitude and resemble prospectors in some ways because they too send out external feelers (high frequency). Simultaneously, they are concerned with maintaining a stable nucleus of activities. Similar to defenders, they do not lose sight of internal efficiencies and prefer externally predictable exchanges (high consistency).

H2: The pattern of coupling between an organization and other organizational actors will be a function of the strategy type(s) that are most similar to the organization’s strategy.

The above hypothesis has received support from the Beekun and Ginn (1993) study referred to previously. Interorganizational coupling varied within the resource exchange and information domains by strategy type ($F_{1,46} = 6.37, p < .05$).
Assessing Technology-Structure Relationships with the Multidimensional Approach

A major impediment in linking technology to structure is the use of different technology definitions by researchers (Doty et al., 1993). We adopt Perrow’s (1970) definition in discussing technology-structure relationships for two reasons. First, statements linking coupling to technological routineness tend to connect coupling to the whole technological process and not to any particular phase of the process. Perrow’s (1970) definition of technology applies to the whole technological process. Finally, the routineness aspect of technology has already been related to coupling (Perrow, 1984).

Perrow (1970) posited that routineness consists of two dimensions: the number of exceptions encountered in the work, and the extent to which the exceptions are analyzable. A routine workflow is characterized by few exceptions and high analyzability; the transformation process is very rigidly laid out, and the stages in the process are sequentially invariant. With reference to differentiation and integration (Lawrence & Lorsch, 1967), a routine workflow is likely to be characterized by low differentiation and require low integration. A nonroutine workflow, however, is characterized by many exceptions and low analyzability; the sequence of activities is not rigid, and nonroutine information is continuously being processed. Larger differences among the participants’ activities and positions can be expected, and reflect greater horizontal differentiation. Since greater differentiation requires more integration (Snook, 2000), a nonroutine workflow is likely to be characterized by high differentiation and high integration.

H3: The pattern of coupling among organizational actors will be a function of the degree of routineness in the workflow.

H3.1: A routine workflow will be characterized by low differentiation and low integration.

H3.2: A nonroutine workflow will be characterized by high differentiation and high integration.

We tested H3 in a field simulation involving 228 organizational participants from eight organizations. A multimethod approach involving questionnaires, self-reports, and archival sources was used to gather network data. Three hundred and fifty-two different activities were mentioned by participants and classified by five independent raters into the six coupling domains described earlier. Any disagreement among the raters was solved by following the modal opinion concerning that activity. As shown in Table 2, interrater reliability estimates (Shrout & Fleiss, 1979) ranged from .74 to .96 for the six coupling domains. The mean reliability for all six domains was .84. This is quite good and supports the differentiation of activities into these six domains of loose coupling.

H3.1 and H3.2 have received partial empirical support with respect to integration. Four of the simulated organizations were involved in a routine core technology whereas the other four simulated organizations were involved in a nonroutine production activity. In general, the less analyzable the task, the greater the need for integration among organizational actors. Thus, in the context of less
Table 2: Interrater reliabilities for coupling domains.

<table>
<thead>
<tr>
<th>Coupling Domain</th>
<th>Interrater Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication activities</td>
<td>.9569</td>
</tr>
<tr>
<td>Workflow activities</td>
<td>.9392</td>
</tr>
<tr>
<td>Bureaucratic activities</td>
<td>.8352</td>
</tr>
<tr>
<td>Resource-exchange activities</td>
<td>.7425</td>
</tr>
<tr>
<td>Structuring activities</td>
<td>.7995</td>
</tr>
<tr>
<td>Social activities</td>
<td>.7889</td>
</tr>
</tbody>
</table>

Analyzable tasks, actors were more dependent on one another in the workflow $(F_{1,226} = 4.09, p < .05)$ and the resource exchange domains $(F_{1,226} = 7.31, p < .01)$, and exchanged resources more directly $(F_{1,226} = 24.85, p < .01)$.

In contrast to routine and nonroutine organizations, firms involved in flexible manufacturing and making use of information technology can achieve the large volume production of routine workflows while turning out the great variety of products characterized by nonroutine workflows (Daft, 1997). Hitt, Nixon, Hoskisson, and Kocher (1999) and Sanchez and Mahoney (1996) suggested that flexible manufacturing would be characterized by high differentiation but low integration, because modularity (high differentiation) needs to be loosely coupled together (low integration) to facilitate adaptability. Modularity was defined by Sanchez and Mahoney (p. 65) as “a special form of design which intentionally creates a high degree of [...] loose coupling between component designs by standardizing component interface specifications.”

H4: Units within a workflow engaged in flexible manufacturing will be characterized by high interunit differentiation and low interunit integration.

Assessing New Organizational Forms with the Multidimensional Approach

The multidimensional approach to loose coupling can also help us understand a relatively new trend—loosely coupled, cooperative interorganizational forms (Kerwood, 1995). Within such forms, structuring is kept to a minimum, and there is little or no common ownership of member organizations. Many organizations in electronics, healthcare, apparel, and steel, etc., are shifting to a dynamic network design (Kerwood; Daft, 1997) or virtual organizations (Grabowski & Roberts, 1998). These organizations use a free-market style to trim down layers of vertical hierarchy. Companies retain a limited number of activities focused on their core competencies while outsourcing other activities to specialist organizations in the supply network.

Dynamic network organizations are likely to differ from organizations with traditional vertical hierarchies in terms of the coupling relationships among their functional areas. Because of their reduced reliance on hierarchical levels, coupling in the structuring domain is expected to be looser for dynamic network organizations than for organizations with traditional vertical hierarchies (Daft, 1997).
Dynamic network organizations are usually spread out geographically. As a result, non-task-related communication linkages will be weak. Conversely, as indicated by Grabowski and Roberts (1998), task-related communication processes will vary in intensity and directness depending on the stage of network formation. Because of the need to coordinate among the network members during the initiation stage when the organization is establishing its goals and measures of effectiveness, coupling in the task-related communication domain (for example, via e-mail) is expected to be tighter (more frequent and direct) for network organizations than for organizations with traditional vertical hierarchies. During the production stage, communication will be less frequent and direct as compared to organizations with traditional vertical hierarchies.

H5.1: Coupling in the structuring domain will be looser in organizations using a dynamic network structure than in organizations using a traditional vertical hierarchy.

H5.2: Coupling in the non-task-related communication domain will be looser in organizations using a dynamic network structure than organizations using a traditional vertical hierarchy.

H5.2.a: During the initiation stage, coupling within the task-related communication domain will be tighter in organizations using a dynamic network structure than organizations using a traditional vertical hierarchy.

H5.2.b: During the production stage, coupling within the task-related communication domain will be looser in organizations using a dynamic network structure than organizations using a traditional vertical hierarchy.

CONCLUSION

A multidimensional framework of loose coupling has been presented here that focuses around three goals. Our paper delineated the nature of coupling elements, the common dimensions linking such elements, the content of coupling relationships in several domains, and the mechanisms connecting elements together. Next, these four components were expressed in network analysis terms to operationalize our multidimensional framework. Finally, this framework was applied to several areas of research. It was used to enrich the resource dependence perspective, to extend the concept of strategic gestalts, and to assess technology-structure configurations more precisely and dynamically. We also provided initial evidence of psychometric and empirical support of the multidimensional approach. Overall, the approach presented here should facilitate the development of loose coupling as a scientific metaphor.

The multidimensional approach to coupling makes several contributions. First, both the coupling and network analysis literature benefit. A network analysis perspective motivates researchers to be more theoretically and methodologically precise about organizational concepts. The translation of loose coupling in network terms also provides network analysis with some of the theoretical depth that its advocates are calling for (Grabowski & Roberts, 1998).
Second, our multidimensional approach broadens researchers’ understanding of interorganizational linkages. A dominant theoretical framework governing the linkage literature is resource dependence. This perspective does not focus either on the functionality of loose interorganizational linkages (Pfeffer & Salancik, 1978), or the domain(s) or dimension(s) characterizing them. The concept of loose coupling can fill in these gaps and provide a more comprehensive view of interorganizational linkage processes. Our multidimensional approach also allows for tracking the covariation between loose and tight coupling, both at the intra- and interorganizational levels of analysis. As a result, longstanding hypotheses about the functionality of loose or tight coupling (Weick, 1985) may be operationalized with greater clarity.

Third, the multidimensional approach to coupling contributes to the strategy and interorganizational linkages literature by extending the Miles and Snow (1978) typology of business strategies. The main thrust of the typology is that a business strategy is a consistent configuration of functional area strategies, and that there are a few highly effective configurations that organizations use to align themselves with the external environment. The application of our model helps to expand the gestalts associated with Miles and Snow’s typology by highlighting the interorganizational coupling patterns of the strategy types.

Fourth, unlike previous measures of fit (Schoonhoven, 1981), the network analysis measures of strength, directness, consistency, and dependence provide researchers with the ability to test for distinctive competence. With respect to Miles and Snow’s (1978) typology, no single strategy type leads to the best performance at all times (Shortell et al., 1990; Doty et al., 1993). By monitoring precisely the links with which external actors are being tightened or loosened, practitioners can correlate these gestalts of loose/tight connections with performance measures. They can then pinpoint which distinctive relationships characterize high performing organizations within each strategy type. Tracking such potential changes is important because what appears tightly (loosely) coupled in the short term may in fact be loosely (tightly) coupled in the long term.

Fifth, flexible manufacturing and complex, nonlinear technologies (Sanchez & Mahoney, 1996) require an assessment of coupling prior to the final design and construction. To the extent that looseness and/or tightness must be built into the flexible assembly line ahead of time, the approach developed here facilitates the assessment of loose/tight coupling accurately and dynamically. Simultaneously, typologies of technology such as Perrow’s (1970), need to be extended to account for mass-customization on a large scale. Our multidimensional approach should enable researchers to map out and design structures congruent with such technologies.

Sixth, the field of organization design is changing as loosely coupled organization forms appear and become exceedingly important within a global context. When two or more organizations combine into a network without the bond of long-term strategic purpose, practitioners will need new tools to monitor and maintain some semblance of stability over time (Kerwood, 1995; Grabowski & Roberts, 1998). Tracking and adjusting such interorganizational linkages dynamically will be facilitated by the approach presented in our paper.

Finally, the multidimensional approach proposed here may benefit the emerging areas of strategic supplier alliances (Monczka, Petersen, Handfield, &
Ragatz, 1998) and supply networks as complex adaptive systems (Choi, Dooley, & Rungtusanatham, 2001). From a buying company perspective, three of the key success factors of such alliances are resource commitment and exchange, interdependence, and information sharing (Monczka et al.). Firms in supplier alliances need to develop competencies in tracking resource exchanges precisely and dynamically, assessing the degree of interdependence between buyers and suppliers, evaluating the timeliness of the information being communicated to one’s supply chain partner, and measuring the strength of bilateral communication linkages (Burt, Norquist, & Anklesaria, 1990; Handfield, 1995). Firms in supply networks also need to understand the degree of network connectivity in the context of dynamic changes among secondary and tertiary-level suppliers (Choi et al.).

The methodology proposed in our paper can facilitate dyadic studies of buyer-supplier alliances, supplier-supplier relationships (Choi et al.), as well as longitudinal studies tracking the processes underlying the success or failure of these relationships in the supply network.

The multidimensional approach to loose coupling, however, is but one perspective that may be used to study coupling relationships. Because it is meant to complement other approaches to loose coupling, several caveats must be advanced to ensure its appropriate use. To begin with, not every aspect of loose coupling can be quantified. For example, Orton and Weick (1990), as well as other coupling theorists, implicitly suggested that loose coupling tends to be functional. What about situations when it is not and leads to practical drift, namely, the “slow steady uncoupling of practice from written procedure” (Snook, 2000, p. 194)? How can coupling be measured when some coupling elements are unaware of certain segments of their surroundings?

Next, our network measures assume that coupling relationships are observable before measurement is possible. Because loose coupling relationships are often difficult to observe, our definitions may lead to a reliance on perceptual measures. Network data also assumes that boundaries can be drawn. Which coupling elements should be included or excluded from an analysis? Previous network analysts have either adopted the subjectively perceived boundaries of the social entity consciously experienced by the actors who are part of the entity (e.g., corporation, movement, family) or have imposed their own conceptual framework (Knoke & Kuklinski, 1982). Neither approach is flawless, but the question of inclusion must be kept in mind.

Finally, network analysis data is difficult to gather because of the repetitive nature of the data-gathering instruments. Threats to internal validity such as mortality can lead to gaps in the network data gathered. A multimethod approach to data gathering can avoid some of these problems, but may sometimes be difficult to implement. As a result, network analysis measures must be developed that will facilitate and encourage very high response rates.

In spite of these drawbacks, the potential of loose coupling to inform practitioners is tremendous. Loose coupling has now been used to advise local governments about performance assessment (Johnsen, 1999); school administrators about the type of linkages that will provide both autonomy and control (Logan et al., 1993); the military about strategies to buffer against catastrophes (Snook, 2000); and managers about the strategies to manage virtual organizations effectively.
Our newfound ability to name and describe the phenomena should make it easier for researchers and practitioners to pay heed to the prescriptive implications of the loose coupling metaphor. [Received: March 10, 1999. Accepted: April 3, 2001.]

REFERENCES


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