

Towards Reconciling Transaction Cost Economics and
The Knowledge-based View of the Firm:
The Context of Interfirm Collaborations

Bruce Heiman*
University of California at Berkeley
Haas School of Business
bheiman59@yahoo.com

Jack A. Nickerson**
John M. Olin School of Business
Washington University in St. Louis
Campus Box 1133
One Brookings Drive
St. Louis, MO 63130-4899
nickerson@wuolin.wustl.edu

July 25, 2001

* This paper is partly adapted from Heiman's dissertation, from University of California at Berkeley's Haas School of Business.

** Corresponding author.

Towards Reconciling Transaction Cost Economics and The Knowledge-based View of the Firm: The Context of Interfirm Collaborations

Abstract

This paper presents a set of relationships that have the potential to reconcile the dispute between the knowledge-based view of the firm (KBV) and transaction cost economics (TCE). Several KBV scholars have argued that governance choice need rely only on bounded rationality and not on opportunism where TCE scholars maintain that both behavioral assumptions are needed to explain governance choice. We help to resolve part of the debate by developing an extension of TCE to encompass certain knowledge-based attributes of transactions. We argue that high-levels of two knowledge transfer attributes—knowledge tacitness or problem solving complexity—lead to the adoption of the knowledge management practices—high-bandwidth channels or idiosyncratic communication codes—to economize on the cognitive limitations of man. It is these knowledge management practices that generate contracting hazards for which TCE, and its attendant concern about opportunism, predicts equity-based collaborations are superior to non-equity based collaborations. The linkages between knowledge transfer attributes, knowledge management practices, and governance choice are not only fills a gap between and TCE but also provide value by providing implications for managers not readily apparent from either theory alone.

Towards Reconciling Transaction Cost Economics and The Knowledge-based View of the Firm: The Context of Interfirm Collaborations

1. Introduction

The topic of knowledge is the focal point of a growing debate in the literature on the theory of the firm. What role does knowledge play in governance choice? Theorists espousing a knowledge-based view (KBV) of the firm (e.g., Conner 1991; Kogut & Zander 1992; Conner & Prahalad 1996; Kogut & Zander 1996) maintain that bounded rationality acts *sans* regard for opportunism as it influences managerial choice of governance for a particular transaction. In dispute, theorists relying on transaction cost economics (TCE) reasoning (e.g., Williamson 1985, 64-7; Foss 1996a, 1996b) maintain that governance mode decisions cannot be explained without relying on the additional behavioral assumption of opportunism.

This paper contributes to the debate and potentially informs certain aspects of it by suggesting an extension of the TCE analysis of governance choice to encompass certain knowledge-based attributes of transactions. We develop our extension somewhat narrowly in the context of inter-firm collaborations and seek to understand how several knowledge transfer concerns influence governance choice.¹ We assert that two knowledge transfer attributes—the degree of knowledge tacitness and the level of problem-solving complexity—engender knowledge transfer problems due to cognitive limitations of man. Managers, we argue, choose to deploy administrative apparatuses within collaborations to mitigate the costs of knowledge

¹ Collaborative activities between firms represent an appropriate area in which to focus the discussion because inter-firm collaborations offer a rich breeding ground for issues surrounding knowledge transfer.

transfer owing to high degrees of knowledge tacitness and problem-solving complexity. By administrative apparatus, we generally mean organizational processes and mechanisms by which systematized activity is carried out. We focus on a subset of administrative apparatuses—knowledge management practices (KMPs)—that are costly to deploy but can reduce knowledge transfer costs by enhancing the richness of communication and hence knowledge transparency between actors transferring knowledge. The KMPs we consider are (1) the choice of and investment in communication bandwidth and (2) communication codes used to transmit knowledge between collaborators.

Following Arrow (1974), we argue that KMPs provide communication channels that economize on man's cognitive limitations by lowering the cost of transferring tacit knowledge and lowering the cost of communication associated with problem solving—a choice that we equate to choosing the most cost-efficient production technology with respect to knowledge transfer attributes. However, the KMPs adopted on cognitive and “production” efficiency grounds give rise to contracting hazards once the behavioral assumption of opportunism is considered. We predict that governance choice for the inter-firm collaboration is made directly with respect to these contracting hazards, an orthodox TCE assertion. Thus, knowledge-based exchange attributes have governance choice implications via the adoption of KMPs. Although we treat these choices sequentially to explicate our theory, we nonetheless view them as simultaneous choice.

The main contributions of our extension are threefold. First, it proposes a plausible set of relationships that integrate factors from both the TCE and KBV perspectives. Second, the paper posits a role for management beyond governance. Managers need to assess the cognitive demands and limitations associated with knowledge transfer and problem solving and choose

KMPs that enhance the efficiency of these activities. Thus, our extension looks at precursors to hazards and explains the production cost reasons why collaborators might expose themselves to such hazards in the first place—something for which extant TCE is relatively silent. Third, our approach is complementary to that of Oxley (1997), who explores the governance implications of the need to safeguard against misappropriation of largely codified, legally protected (e.g., patented) knowledge, by probing how appropriability concerns for unprotected, uncodified, embedded knowledge influence governance choice.

The next section explores in more detail the boundary choice debate between KBV and TCE, with emphasis on the KBV. Section 3 develops our extension by first presenting implications for the adoption of administrative apparatuses based on the assumption that man is cognitively limited and then drawing implications for governance based on the added assumption of opportunism. Section 4 discusses our extension and Section 5 concludes.

2. The Debate

The debate between scholars researching the knowledge-based view of the firm (KBV) and transaction cost economics (TCE) erupted in the September 1996, issue of *Organization Science*. In that issue, Foss (1996a: 470) argued that the knowledge-based theory for the existence of a firm, put forward by Kogut & Zander (1992), “erred in the specific way in which they claimed that a distinct theory of...the firm can be constructed on the basis of a theory of organizational knowledge or from resource-based insights.”² Acknowledging a role for bounded rationality in the theory of the firm, Foss (1996: 473) stated that “the kernel of truth in

² Foss also responds to Conner (1991) and Conner & Prahalad (1996) who argue that hierarchy offers knowledge-substitution and flexibility advantages assuming no opportunism. Because of our focus on interfirm collaborations we do not directly address this argument. For a related discussion that addresses both Conner & Prahalad (1996) and Kogut & Zander (1992), see Nickerson & Zenger (2001).

technological determinism is that different technologies yield different constellations of transaction and information costs, and therefore loosely influence economic organization...But the influence is indirect and the linkage is not tight.” Thus, Foss (1996: 473) describes Kogut & Zander’s work as symptomatic of Williamson’s (1985: 87) technological determinism, which neglects the possibility of opportunistic behavior. A theory of boundary choice, Foss asserts, rests additionally on the possibility of opportunistic behavior.

In response to Foss, Kogut & Zander (1996) essentially argue that governance decisions, such as the canonical choice between market and hierarchy, can indeed pivot on bounded rationality alone. Kogut & Zander (1996: 503) argue "that a firm be understood as a social community specializing in the speed and efficiency of creation and transfer of knowledge.” This view is consistent with their earlier article (Kogut & Zander, 1992: 384) where they claim that “firms exist because they provide a social community of voluntaristic action structured by organizing principles that are not reducible to individuals.” They assert that “the central competitive dimension of what firms know how to do is to create and transfer knowledge efficiently within an organizational context” (Kogut & Zander, 1992: 384).

The foundation of their argument is that “[f]irms provide the normative territory to which members identify” (Kogut & Zander, 1996: 506, emphasis added), which has two implications. “First, it defines conventions and rules by which individuals coordinate behavior and decision making... Second, identification sets out the process by which learning is developed socially through the formation of values and convergent expectations” (506). Hierarchy, in their view, offers advantages over markets because the former can create an identity, which leads to social arrangements that support coordination and communication, which the latter cannot (502). These “hierarchy-enhanced” coordination and communication capabilities allow firms to create

and internalize complex, difficult-to-codify knowledge. Kogut & Zander (1996) assert “reasonable support for the proposition that more tacit knowledge is slower to be transferred and that firms tend to transfer tacit knowledge within the firm instead of through the market” (503).

In a critical response, Foss (1996b: 520) asserts that after boiling down the arguments, one sees that “[t]he ultimate argument for firm organization in Kogut & Zander’s reasoning is some postulated wish to belong to [identify with] a moral community; firms exist because they fulfil this desire.” Even granting this “specific preference” for a moral community, an essentially non-economic explanation, Foss (1996b: 520) states “it is not at all clear in this story why firms are necessary for realizing moral communities and bringing shared identities” (emphasis in the original).

Foss is not alone among TCE scholars in his critique of the knowledge-based view.

Oxley (1995: 57-58) likewise casts doubt on a “pure” resource- or knowledge-based orientation:

...[T]he advantages of hierarchy in reducing the costs of technology transfer do not appear to hinge on the features of incentive alignment and administrative controls per se, but rather on communication, labor mobility and organizational routines. Closer examination suggests that the feasibility problem in technology transfer is not unrelated to appropriability, however. If we delve into reasons why the activities needed to effectively transfer the technology cannot be achieved via contract between autonomous parties, the main problem seems to be in fully specifying the transaction and preventing leakage of the know-how embodied in the personnel (other than that which is specified for transfer by the contract).

Oxley (1995: 58) subsequently identifies factors affecting knowledge transfer: “The most important factors affecting technology transfer costs...include (1) the complexity and age of the technology (since new technologies tend to be less well codified), (2) the technological capabilities of the recipient firm, or the firm’s “absorptive capacity” (Cohen & Levinthal, 1990) and (3) the amount of previous experience the firms have with technology transfer.” Each of

these factors maps to “associated contractual hazards” (58), which Oxley claims affect governance mode choice.

While writers from a TCE perspective criticize the KBV, we assert that TCE nevertheless has its own shortcomings. The TCE literature on appropriability is nascent, particularly with respect to the empirical aspects of tacit, unprotected (e.g., unpatentable) knowledge. TCE also does not provide a clear explanation for Kogut & Zander’s (1993) empirical observation that firms are faster and more efficient than markets at transferring knowledge. Moreover, TCE has yet to cogently link knowledge-related transaction attributes with behavioral (opportunism) hazards. We attempt to address these weaknesses in the section that follows.

3. From Knowledge Transfer Attributes to Governance

Our extension is based on the transaction as the unit of analysis in which the primary activity is knowledge transfer. We begin our theoretical development by assuming only that economic actors are cognitively limited and exploring how knowledge transfer attributes interact with cognitive limitations to influence the choice of KMPs. We then add the assumption of opportunism to predict how the adoption of KMPs simultaneously affect the choice of governance for interfirm collaborations.

3.1. Knowledge attributes and the cost of knowledge transfer

A fundamental problem in many collaborations relates to the transfer of knowledge. Knowledge transfer is costly. Indeed, Hayek (1945) treats knowledge as so idiosyncratic that most specialized knowledge may not be transferable, or is only transferable at prohibitive cost. Knowledge transfer costs arise because of cognitive limitations. For instance, Simon (1945: 40-41) argues that human minds are limited in the rate at which knowledge can be assimilated, in

the amount of knowledge that can be accumulated, and in the amount of knowledge that can be applied. Such limitations are important to administrative theory because it raises questions of:

... how specialization in the administrative organization is to be related to the specialization with the endowments of knowledge that are prevalent in the community's occupational structure; how the system of communication is to channel knowledge and information to the appropriate decision-points; what types of knowledge can, and what types cannot, be easily transmitted; how the need for intercommunication of information is affected by the modes of specialization in the organization (Simon, 1945: 40-41).

Individual characteristics notwithstanding, knowledge transfer costs differ by the nature of the knowledge to be transferred and by the administrative organization adopted to support the transfer. This subsection examines the first of these concerns: how the cost to transfer knowledge differs by the nature of knowledge intended for transfer and the associated knowledge transfer task.

The focus here is on two attributes of the knowledge transfer task that affect transfer costs: knowledge tacitness and joint problem-solving complexity. The first attribute concerns the degree to which knowledge to be transferred is tacit. Knowledge tacitness refers to how particular knowledge is stored with respect to three dimensions: human/physical, informal/formal, and linguistic/formulaic.³ The cost to transfer knowledge involves, among other things, verifying that the recipient accurately understands the knowledge received.⁴ Such costs

³ Heiman (2001) argues that the three "poles" of these dimensions (human, informal and linguistic) are positively correlated with the cost of knowledge transfer because they indicate the degree of tacit knowledge, which has implications for the cost-effective method of transfer. We note that though these indicators may converge somewhat at the tacit end of the spectrum, perhaps owing the nature of tacitness itself, they are clearly distinct at the codified end of the spectrum, which renders them suitable for use as measures. We can operationally specify knowledge as embodying a high degree of tacitness by looking at the extent to which it is not stored via physical, formal and/or formulaic means. These empirically tractable dimensions can be evaluated qualitatively by asking individuals, who possess or are aware of certain knowledge, how that knowledge is stored without directly requiring full elucidation of the knowledge. The indicators we describe provide a tractable but second-best metric for indicating the relative cost to transfer tacit knowledge.

⁴ Costs of knowledge transfer that are not considered herein include the costs of indexing, maintaining, and upgrading (including supplanting) knowledge.

are a reflection of the limited rate at which individuals can assimilate knowledge. With knowledge that is represented via physical, formal, or formulaic means, verification costs are low as the recipient can verify the knowledge by inspecting its physical representation, referring to its formal representation, or logically interpreting its formulaic representation. In contrast, when knowledge is stored in humans, informally, or linguistically, the recipient can only verify knowledge by transferring it back to the sender who must then provide the verification. The entire transmission sequence must be repeated if the recipient's initial understanding of the knowledge is inconsistent with knowledge received by the original sender, which incurs additional costs. Thus, verification costs are likely to increase with the tacitness of the knowledge transmitted, which increases knowledge transfer costs.

Proposition 1A: As the degree of knowledge tacitness associated with collaborative activities increases, costs associated with knowledge transfer increase, ceteris paribus.

The second attribute, joint problem-solving complexity, concerns the degree to which problem solving in an exchange is complex.⁵ Assuming that relevant knowledge for solving a problem is dispersely held among actors, such complexity is subject to cognitive limits of the accumulation and application of knowledge, which increase knowledge transfer costs as complexity increases. Simon (1962: 472) notes that problem solving "...usually involves a great deal of trial and error. Various paths are tried; some are abandoned, others are pushed further...The more difficult and novel the problem, the greater is likely to be the amount of trial

⁵ Complexity is defined herein based on an adaptation of Simon's (1962) seminal contribution, which explains complexity in natural hierarchic systems and how this may be applied to organizations. Complexity exists in a collaboration if, in order for successful execution of a collaboration's mission to be achieved, distinct knowledge sets must be combined, which results in new knowledge, and the new knowledge has long-term performance implications for the collaboration. Complexity increases with the number of distinct knowledge sets relevant to solve a problem and produce new knowledge—for a more extensive elaboration see Heiman (2001).

and error required to find a solution.” Finding solutions to complex problems must rely on more than random trial and error—because, otherwise, the likelihood of randomly locating a valuable solution quickly decreases as problem complexity increases (Simon, 1962).

The key to economically arriving at a successful solution is to combine relevant knowledge sets to rank-order trials so that the potential solution with the highest expected value is tried first, the next most likely solution is tried second, and so forth. Moreover, the speed and likelihood of finding a solution is enhanced by evaluating results after each trial and again combining knowledge to choose the next trial. Combination of relevant knowledge sets improves the likelihood of finding valuable solutions to complex problems because it provides insight into the shape of the terrain of the solution landscape (Flemming & Sorenson, 2000). Developing such a cost-effective rank ordering benefits from the full use of all knowledge-sets relevant to the problem when complexity implies a high level of interaction among knowledge sets. Developing a rank ordering based on only a subset of the relevant knowledge sets is likely to diminish the likelihood of finding a valuable solution because high levels of interaction render rank ordering based on such a subset little better (and perhaps worse) than random trial selection.

In collaboration, knowledge sets from the various partners must be transferred among each other in order to collaboratively choose trials; else, different knowledge sets held by the differing actors will likely either diminish the likelihood of finding a valuable solution or lead to conflict in trial selection, which would slow and possibly halt progress towards finding a solution. As a problem increases in complexity so too does the number of distinct specialized knowledge sets and, because of cognitive limitations, the number of actors involved in transferring and receiving knowledge. Moreover, the greater the number of knowledge sets to be transferred the more costly such transfer is on the margin because cognitive limitations of human

ability to accumulate and apply knowledge are increasingly likely to be reached, rendering transfer less effective and less complete and thereby further increasing transfer costs.

Proposition 1B: As the degree of complexity associated with problem solving increases, costs associated with knowledge transfer increase, ceteris paribus.

Evidence exists for the pernicious effects of these knowledge attributes on performance in collaborations. Regarding the effects of problematic knowledge attributes on the success or failure of collaborations, Borys and Jemison (1989) acknowledge the impact of tacitness on the instability of cooperation by noting that technology transfer agreements whose purpose is the transfer of tacit knowledge and expertise tend to break down comparatively more often than those involving the exchange of readily codifiable (non-tacit) technology.

Regarding complexity, Speier et al. (1999) show, through a series of experiments, that for highly complex tasks, disruptions negatively impact task performance. As frequency of interruptions and dissimilarity of content between the primary and interruption tasks increase, a significant decrease in decision-making performance occurs, which implies that knowledge transfer costs increased with complexity. Speier et al.'s study supports the contention that a high degree of complexity negatively affects performance of tasks, at least in an artificial environment.

Using clever thought-experiments, Radner (1992) demonstrates the extraordinary sensitivity of problem-solving complexity to small changes in work practices. Efficiency-impairing task-performance difficulties rapidly ensue when executing tasks inside hierarchic organizations, even given stylized, small teams, simple tasks and simple structures. Problems quickly become less tractable as team size or structural complexity is increased, even to a small extent. Radner's work leads one to expect that the efficiency of solving complex problems might be greatly enhanced by practices that reduce execution problems.

Lam's (1997) work implicates complexity as a cause of poor knowledge transfer performance. She shows that differing cultural settings influence the degree of difficulty associated with the transfer of tacit knowledge. Additionally, she shows that strategic alliances involving firms from different national cultures frequently fail as a result of the substantial (unintended) asymmetries in the ability to transfer knowledge. These studies establish the cost-increasing effects of tacitness and problem solving complexity.

3.2. Knowledge management practices and information costs

Adam Smith (1776) and, later, Fredrick Taylor (1911) popularized a theory of cost-efficiency in production activities through increased specialization of workers' skills. Their influential approach asserts that returns to investment increase with greater specialization of people's skills. Given, however, knowledge transfer as the productive activity, Hayek (1945) and Penrose (1959) note the efficiency-impairing costs of specialization for knowledge transfer activities (these efficiency impairing costs are discussed below). Thus, specialization, while creating productive efficiencies, creates impediments to the transfer of knowledge and to finding solutions to complex problems involving multiple sets of specialized knowledge. Arrow (1974) argues that these knowledge transfer impediments can be reduced by the choice of and investment in information channels and communication codes within organizations. In discussing these choices and investments, Arrow (1974: 48) states that his "... point of view is that of an optimizing model but in a rich framework of uncertainty and information channels...the acquisition of information must be analyzed since it is itself the result of decisions." Before discussing such optimizing decisions, we discuss the administrative apparatuses managers can choose from to affect knowledge transfer costs.

Arrow places his focus squarely on the need to understand how managers choose information channels and communications codes (and accompanying costs) that enable the transfer of knowledge in organizations. For instance, Arrow (1974: 37) asserts that

...the presence or absence of information channels is not prescribed exogenously to the economic system, channels can be created or abandoned, and their capacities and the types of [coded] signals to be transmitted over them are subject to choice, a choice based on comparison of benefits and costs.

Information channels are the communications conduits through which coded signals flow.

Arrow (1974: 39) distinguishes between physical aspects of communication, telephone lines and the like, and the investment in time and effort to be able to distinguish one signal from another, codes. We discuss each separately below.

Channel Bandwidth: The physical aspects of information channels refers to the bandwidth of communication that can be delivered by alternative means. The bandwidth of a transmission—hereafter referred to as an interaction—refers to the degree of intensity of communication among individuals. Although the choice of bandwidth falls along a continuum, for simplicity of exposition only high- and low-bandwidth channels are considered here. High-bandwidth interactions involve tight, rich, immediate interfaces between partners, and are generally relatively costly in terms of time and effort. A high-bandwidth interaction is intended to facilitate a high degree of rich context, high-affect, and high-transparency in communications between partners. High-bandwidth interactions provide easy access to knowledge by allowing, for example, physical demonstrations, immediate redundancy and restatement (rephrasing), high clarity, rich contextual cues, high interactivity, and clear emphases.

Low-bandwidth interactions, in contrast, are characterized by low-context communications measures: for example, email, faxes, letters, and phone calls. Low-bandwidth interactions offer little clarity of emotional affect, low or no redundancy, time-lagged (sometimes

severely) queries and responses, low interactivity, very low or no contextual cues, and comparatively less clear emphases. Generally, low-bandwidth interactions provide low degrees of knowledge transparency at comparatively low cost, versus high-bandwidth interactions, which provide high transparency albeit at a high-cost.

The following example illustrates the effects of high-bandwidth interaction on a collaborative activity. Tacit knowledge of a particular automated manufacturing line's yield-enhancing nuances and yield-impairing operational quirks are difficult to transfer to a partner whose employees lack operating experience with highly similar or identical automated production lines (the knowledge of the operating nuances is tacit). Inexpensive, low-efficacy low-bandwidth interactions offer little or no relief: simply passing along binders full of articulated, codified knowledge of the production operation fails to direct attention to the nuances needed for actual machine operation (which evokes Polanyi's (1962: 52) illustration of using a light bulb manufacturing machine). High-bandwidth interactions increase transparency of the knowledge and facilitate its transfer. For example, interactions via frequent in-person meetings, multiple plant tours, personal training, reviews of specifications, and in-depth discussions would facilitate the transfer of the "nuanced" knowledge to the extent possible.

Co-location, which is often mentioned in empirical studies, is a polar form of a high-bandwidth interaction and occurs when two partners share a common collaboration site for work activities pertinent to the collaboration. In co-location, the shared work site may be located at one or another partner's facility, a neutral (unaffiliated) site, or alternate between partner-firms' sites. Extensive co-location was observed by von Hippel (1994) in response to problems with "sticky" information. Von Hippel (1994: 429) found that "...when sticky information needed by problem solvers is held at one site only, problem solving will be carried out at that locus, other

things being equal.” He also observed that specific sticky information is associated with specific sites, and, in the case of multiple loci of sticky information, activities iteratively alternate between loci (432). Von Hippel proposes co-location as a cost-reducing remedy for sticky information problems in activities involving knowledge.

Communication codes: Arrow (1974: 39) claims that an important aspect of information costs are the costs of rendering human minds suitable to receive coded signals that comprise knowledge to be transferred. Individuals have to make an adequate investment of time and effort to be able to distinguish one signal from another and these are in part idiosyncratic and irreversible capital costs. For instance, Arrow (1974: 39) states:

Learning a foreign language is an obvious example of what I have in mind. The subsequent ability to receive signals in French requires this initial investment. There are in practice many other examples of codes that have to be learned in order to receive messages; the technical vocabulary of any science is a case in point...Such investment, being locked up in an individual's mind, is necessarily irreversible.

Use of codes allows the sender to transform his knowledge into a signal and allows the recipient of a signal to understand it. The mutual adoption of codes is a form of idiosyncratic co-specialization that lowers knowledge transfer costs by increasing mutual understanding, which increases the extent of knowledge that can be shared between partner-firms. In collaborations, co-specialization represents a specific, irreversible investment by a partner-firm in its relation with another partner-firm. Another example of co-specialization is found in an international collaboration, if members of one partner-firm undergo cultural and language training to enhance their ability to work with and understand another partner's ways of thinking and working. The trained partner's team-members will have invested in codes to positively affect the efficacy of knowledge transfer in the collaborative activity.

We view the choices of bandwidth and codes as managerial practices that can be adopted to manage knowledge transfer and problem solving activities. Hence, we label the choice of high-bandwidth and co-specialized codes as knowledge management practices (KMPs).

3.3. Matching KMPs with knowledge attributes

Arrow (1974: 55) posits that managers choose their communication channels “with a view towards cost minimization” based on their costs and benefits. We argue that managers can choose the KMPs of channel bandwidth and communication codes to economize on knowledge transfer. These choices hinge critically on the impact on knowledge transfer costs of knowledge attributes.

The more tacit the knowledge to be transferred, the more likely that using high-bandwidth channels will provide greater net benefit than low-bandwidth. The transfer of tacit knowledge benefits from high-bandwidth channels because it provides rich context, high-affect and high-transparency, and real-time verification of the knowledge transferred. As described earlier, low-bandwidth channels are poorly suited for conveying such knowledge and are slow and costly for verifying that the knowledge has been correctly assimilated. Of course, low-bandwidth channels are better suited than high-bandwidth channels for transmitting codified knowledge since verification is trivial or not necessary.

Costly idiosyncratic investment in communication codes, on the other hand, offers little benefit for the transfer of tacit knowledge. Tacit knowledge stored via largely human, linguistic, or informal means implies that specialized codes have not yet been developed to facilitate sending and receiving coded knowledge. Since the cost to codify such knowledge increases with the degree of tacitness and adds to the idiosyncratic cost of learning the code, is likely that the

net benefit of investing in communication codes decrease as the degree of tacitness increases.

Thus, we propose:

Proposition 2A: As the degree of tacit knowledge to be transferred in a collaboration increases, organizations will increasingly adopt the KMP of using high-bandwidth communications, ceteris paribus.

When the degree of problem-solving complexity is high, multiple distinct knowledge sets must be combined, which results in the creation of new economically valuable knowledge. In the context of collaboration, this implies that multiple specialists must transfer their respective knowledge sets as well as assimilate the knowledge of others, a process of combining assets previously identified as co-specialization (Teece, 1986). Moreover, these specialists must frequently engage in knowledge transfer as feedback from each trial; this not only requires interpretation but also requires additional knowledge transfers to identify the next highest probability trial. It is precisely in this situation that idiosyncratic investment in specific communication codes is likely to offer much benefit by lowering communication costs and speeding knowledge transfer. These benefits are likely to rise with complexity owing to economies of scale and scope. Increasing complexity implies an increasing number of distinct knowledge sets, which likely increases the number of specialists involved in knowledge transfer. The adoption of codes among these specialists represents an economy of scope. Increasing complexity also implies frequent transmissions of signals along each communication channel, which gives rise to an economy of scale in each channel should codes be adopted. Codes for a large number specialists may be shared by applying the KMP of investing in creating mutual

understanding of codes thought to be cogent. Such benefits lead to more rapid and precise trial selection and, ultimately, speed the identification of a valuable solution.⁶

Proposition 2B: As collaborative problem-solving activities increase in complexity, organizations will increasingly adopt the KMP of investing in idiosyncratic communication codes, ceteris paribus.

Some evidence for the idea that KMPs reduce the costs of tacit knowledge transfer exists in the literature of technology-mediated communication. Daft & Lengel offer several notable contributions. Daft & Lengel (1984) find that as organizations increase the information richness for solving problems, the ease of information processing increases. In pushing their investigative envelope further (1986), they also find that the mechanisms of debate and clarification, which are available given a high degree of information richness, mitigate problems with knowledge tacitness. In their most related work, Daft & Lengel (1987) find that managers select the lowest feasible level of information richness that facilitates an activity's economical execution. This can be interpreted as choosing channel bandwidth in an economizing manner to match the degree of knowledge tacitness.

Assertions regarding the cost-mitigating effects of co-location are supported by empirical evidence beyond that offered by von Hippel's (1994) work, mentioned above. Patti et al. (1997), using a sample of 82 firms and Spearman's rho to show co-location is positively and significantly associated with increased face-to-face meetings and increased face-to-face meetings

⁶ Investment in learning a code, however, suggests there may be little benefit from the expense incurred in the application of high-bandwidth communication—codes, by definition, can be effectively communicated through low-bandwidth channels without impairing knowledge assimilation. Alternatively, as mentioned above, a high degree of tacit knowledge may decrease investment in communication codes even when complexity is present. These alternatives suggest that there may be interactions when both complexity and the level of tacit knowledge are great that yield nuances, in terms of KMP adoption, not predicted in Propositions 2A and 2B. However, developing a theory of these interaction effects is beyond the scope of this paper.

are positively correlated with on-schedule performance (a borderline-significant correlation was detected between face-to-face meetings and product quality). Using an analysis of sequential network data, Van den Bulte & Moenaert (1998) proffer results indicating "...that communications among teams was enhanced after co-locating these teams." Their study explored the co-location of R&D, manufacturing and marketing teams. Their findings are consistent with the view that co-location acts as an economizing KMP for reducing costs associated with problems engendered by problem-solving complexity.

Simonin (1999), in the course of an exploration of causal ambiguity, discusses complexity as "expected to affect the comprehension of the totality of a [knowledge-] asset and to impair its transferability (p.600)." Simonin (p.600) offers a somewhat broader definition of complexity that roughly echoes the one used in this work: "Complexity refers to the number of interdependent technologies, routines and individuals linked to a particular knowledge or asset." Simonin also notes that complexity has impairing effects on performance as established by Kogut & Zander (1993) wherein they observe a preference for intra-firm transfer of complex knowledge over inter-firm transfer. Rather than accept Kogut & Zander's leap from problematic knowledge attributes directly to governance choice, Simonin asserts that high degrees of problem-solving complexity influence the deployment of remedial measures in organizations.

Our discussion has relied on the assumption of cognitively limited actors. These limitations when coupled with the exchange attributes of tacit knowledge and problem solving complexity lead to the adoption of KMPs that economize on communication costs. We next consider the added assumption of the potential for opportunistic behavior and evaluate the relationship between KMPs and governance.

3.4. KMPs and behavioral (opportunism) hazards

The adoption of either high-bandwidth channels or communication codes severely limits the ability to specify, monitor, and enforce property rights of the knowledge to be transferred, which gives rise to knowledge appropriation hazards (Oxley, 1997). Additionally, the idiosyncratic nature of investment in communication codes may lead to under-investment that lowers the performance of problem solving efforts. Thus, contracting hazards arise because KMPs are adopted to economize on knowledge transfer and problem solving activities.

Hazards arising from high-bandwidth interactions. High-bandwidth channels not only allow for increased efficacy of knowledge transfer, but also amplify knowledge-appropriation hazards that arise with tacit knowledge. Enforcing and delineating precise property rights for tacit knowledge in transactions is generally difficult and costly (Teece, 1981). Specifying ex ante which knowledge to transfer is rendered infeasible because of the tacit nature of knowledge. This problem is exacerbated by a high-bandwidth channel because it increases the transparency of tacit knowledge and increases the difficulty in monitoring exactly what tacit knowledge is transferred. Such transparency makes it easy for a transmitter of knowledge to transfer more knowledge or for a recipient to ask questions to extract more knowledge than was anticipated ex ante, especially when those negotiating ex ante do not possess the tacit knowledge in question. Thus, the knowledge-appropriation hazard increases with the extent that knowledge is tacit given the use of high-bandwidth channels for transferring the tacit knowledge.

Hazards arising from co-specialization. Co-specialization engenders both appropriability and underinvestment hazards. Even though knowledge for problem solving activities may be codified or codifiable, ex ante contracting remains problematic. Ex ante specification of which knowledge sets to combine in a problem solving activity requires deep understanding of all

cogent knowledge sets. If the needed level of understanding is already possessed, then no transaction for the purpose of combining the knowledge is needed. Alternatively, the knowledge could be transferred to facilitate specifying the contract but doing so confronts the Arrow information paradox—once transferred the knowledge has in effect been acquired without cost (Arrow, 1973). Thus, contracts for transactions involving problem solving activities remain incomplete, which gives rise to an appropriability hazard.

Like high bandwidth channels, co-specialization exacerbates the appropriability hazard. Co-specializing communication codes eases cognitive limitations to knowledge transfer, generally increasing knowledge transparency. Without contracts that specify which knowledge is to be transferred, the transmitter may transfer more knowledge or a recipient may ask questions to extract more knowledge than was anticipated *ex ante*. The more complex the problem, the greater the appropriability hazard as more knowledge sets are exposed to possible expropriation. Thus, the knowledge-appropriation hazard increases with the extent to which problems are complex given the use of co-specialized communication codes for transferring the tacit knowledge.

Co-specialization, because of the idiosyncratic nature of the investment in communication codes, also can engender underinvestment. Individual actors may not want to use their limited cognitive capacity to invest in others' communication codes because they could instead increase returns to investment by deepening or using their own specialized knowledge. Thus, individuals may underinvest in communication codes thereby increasing problem solving costs and reducing the speed and likelihood of arriving at a valuable solution.

As an example of these concerns, Shuen (1993) describes two firms in the semiconductor industry that make choices as to which knowledge they acquire during a joint, applied research

project routinely involving co-specialization of technical knowledge. Using in-depth interviews, in one case study she found that one partner focused on acquiring process aspects of a new production technology while the other partner concentrated on obtaining knowledge pertaining more directly to deliverables. There was little evidence that either partner was explicitly aware of the other's intentions as to knowledge acquisition. While her analysis lacks a discussion of the appropriation issues and KMPs that give rise to them, her findings underscore the idea that firms act opportunistically within a collaboration to expropriate knowledge. See also, Hamel et al.'s (1989) discussion of knowledge transfer hazards between Japanese and U.S. collaborators.

In response to these hazards, TCE predicts that far-sighted actors will adopt safeguards to protect against such opportunistic behavior. The standard transaction-cost thrust (Williamson, 1975; 1985; 1991) applies to the final stage in the proposed causal chain, which refers to the relation between opportunism hazards and governance choice: "Transaction cost economies are realized by assigning transactions (which differ in their attributes) to governance structures (which are the organizational frameworks within which the integrity of a contractual relation is decided) in a discriminating way." (Williamson, 1985: 41). One potential safeguard is the bilateral exchange of hostages (Williamson, 1991). For transactions involving knowledge, however, neither partner has any way of (1) knowing whether they have given or received knowledge hostages (in the case of tacit knowledge) or (2) knowing the value of those hostages (in the case of problem solving complexity) due to the inherent measurement problems described above. Thus, the bilateral exchange of knowledge for the purpose of safeguarding the exchange is an infeasible institutional support.

Given the presence of significant opportunism hazards, actors, using an economizing calculus, choose governance for collaborations that safeguards against the threat of opportunism

(Oxley, 1997). While a variety of alternative modes with respect to interfirm exchanges can be comparatively assessed, the literature typically compares equity-based to non-equity based governance alternatives for organizing inter-firm collaborations (e.g., Oxley, 1997). (Since the primary value added of our extension does not come from a restatement of now standard TCE, we limit our brief discussion on governance choice to these two alternatives.) The thrust of these comparisons is as follows.⁷ Whereas non-equity based governance is comparatively low-cost to set-up and run, it provides few safeguards against appropriability or underinvestment concerns. Conversely, equity-based governance is expensive to set-up and run but has the advantage of providing safeguards against appropriability or underinvestment. Thus, the net benefit of non-equity based governance is greater than equity-based governance when contracting hazards are low but the reverse obtains when contracting hazards are great. Since contracting hazards increase with KMPs, we propose that:

Proposition 3: The deployment of KMPs increases the likelihood of choosing equity-based governance over non-equity based governance to safeguard against opportunism increases, ceteris paribus.

⁷ Oxley (1995, 63-64) describes the benefits of specialized governance:

The governance features of hierarchy work to mitigate appropriability hazards in several ways: lower-powered incentives (and alignment of incentives with the seller) reduce the likelihood that the buyer will violate the terms of the agreement; the administrative controls available within hierarchy increase the ability to monitor the activities undertaken in the course of the agreement and allow greater direction of those activities; and the reduced reliance on court ordering for dispute resolution (in the limit, forbearance) decreases the requirements for third party verifiability.

The benefits of specialized governance, however, do not come without certain costs. Oxley (1995, 64) maintains that:

Attenuated incentives mean that the technology may not be exploited in its best use, or to its fullest extent. Thus, internal organization will be reserved for cases in which contractual hazards are at their height, and a hybrid governance structure may be the preferred solution for transactions with 'mid range' appropriability hazards.

4. Discussion

Our extension of TCE offers a plausible reconciliation between the knowledge-based view of the firm espoused by Kogut & Zander (1992; 1996) and TCE (Williamson, 1975; 1985; 1991; Oxley, 1997). High-levels of knowledge transfer attributes—knowledge tacitness or problem solving complexity—lead to the adoption of KMPs—high-bandwidth channels or idiosyncratic communication codes—to economize on the cognitive limitations of man and that these practices generate contracting hazards for which TCE, and its attendant concern about opportunism, predicts the more advantageous it is to rely on equity-based collaborations compared to relying on non-equity based collaborations. Unlike prior work that connects knowledge problems directly to governance choice, this work unpacks the relationship by first considering the affect of cognitive limitations and then considering opportunism. This separation, although admittedly artificial and only for the purpose of elucidating the perspective, is necessary to understand the choice of information channels and governance.

Figure 1 schematically illustrates the set of relationships we propose. The figure also clarifies our contribution. The conflict between KBV and TCE (the unit of analysis notwithstanding) arises because KBV essentially predicts a direct relationship between knowledge transfer attributes and governance whereas TCE predicts a relationship between KMPs and governance. We argued that both theories overlook the relationship between knowledge transfer attributes and KMPs, which necessitate decisions regarding choice of communication channels. Cognitive limitations are assumed for both sets of relationships; opportunism is assumed only for the latter relationship. Our logic predicts a relationship between knowledge transfer attributes and governance choice—the beginning and end of our set of relationships—that is consistent with Kogut and Zander’s empirical observation but does not

obviate the assumption of opportunism. Previous work that claims such integration typically fails to fully consider the critical assumption of possible opportunistic behavior (e.g., Madhok, 1996).

Our perspective has other advantages over existing knowledge-based views of the firm. Unlike Kogut and Zander (1996), who mention that organizing principles and structure are central to a firm's capabilities but do not provide a list of these structures, the view proposed here delivers an initial installment of a parsimonious set of structures—knowledge-management practices—that provide information processing benefits for high levels of knowledge transfer attributes.⁸ Moreover, the knowledge attributes and KMPs discussed are operationalizable because they can be used to characterize knowledge *sans* complete comprehension of the underlying knowledge. Our perspective is thus empirically tractable. Since we generate not only equivalent predictions to Kogut and Zander but also richer predictions with respect to the choice of communication channels with our assumptions of cognitive limitations *and* opportunism, we question the benefit of pursuing a knowledge-based view of the firm *sans* opportunism.

⁸ These structures also resonate with the information processing view of the firm. For instance, Galbraith (1974) predicts that the locus of decision-making changes as the information processing ability of the extant organization reaches its limits. He describes how information processing needs increase with task uncertainty, which calls for organization design strategies that either reduce the need for information processing or increase the capacity to process information. Van de Ven et al.'s (1976) research echoes this view by discussing the use of three coordinating mechanisms—impersonal, personal, and group coordinating modes—in response to increases in task uncertainty and task interdependence. While KMPs are certainly related to these coordinating mechanisms and can be viewed as organizational design strategies that respond to information processing needs, our approach and the information processing view of the firm differ in their focus. Our framework centers on attributes of knowledge and why different knowledge-management practices might be adopted because of these attributes as opposed to the level of task uncertainty or task interdependency. It is also interesting to note that Galbraith and Van de Ven et al.'s research do not consider idiosyncratic communication codes as response to increases in information processing needs. Moreover, the information processing view of the firm assumes firm boundaries as given where our approach does not, which implies that our approach may be able to make predictions about the governance structure of interfirm collaborations whereas the information processing view can not.

One possible reason for this pursuit is that identity is a useful and necessary concept to understand knowledge transfer and is (admittedly) treated largely as a by-product of the processes discussed herein. Our extension relates to Kogut & Zander's (1996) view that knowledge embedded in social relations matters with respect to the efficiency of creation and transfer of knowledge; however, it casts a different light on Kogut & Zander's claim that a firm should be understood primarily as an identity-providing social community that specializes in the speed and efficiency of creation and transfer of knowledge. Our perspective relates to identity in two ways. First, Kogut and Zander's use of identity is consistent with a convergence in interests, which, in our view, implies that identity reduces the likelihood of opportunistic behavior. The importance of this convergence for governance is echoed by Arrow (1974: 69-70), who argues that so long as communications costs are low the "identity of interests" can avoid conflict and allow for consensual decision making, and Williamson (1985), who discusses the effect Malmgren's (1961) convergent expectations on governance choice. Second, even without such a convergence of interests, a firm can have an identity associated with the communication channels and codes developed—Arrow argues that codes within firms generally can be expected to be unique, which thus provides a type of identity. It is the idiosyncratic investment in these channels that may endogenously give rise to a commonality of interests because self-interest and the loss of value incurred by moving to another organization provide an incentive for actors within an organization to engage in joint value maximization more so than in a market, where such investments would likely not be made. Thus, to the extent that self-interest is a behavior consistent with opportunism, identity may be the bi-product of cognitive limitations and opportunism rather than to fulfill individuals' desire to belong to a moral community, which is

Foss's interpretation of Kogut & Zander. More importantly, it would appear that the concept and benefits of identity are not unique to the KBV.

KBV has been delineated by its assumption of not relying on opportunism. We think this delineation is misplaced. Instead, we believe that KBV is better delineated by a focus on knowledge transfer attributes and on the effect of these attributes, directly and indirectly, on the choices of communication channels and governance—in other words, a delineation based on the phenomena instead of the assumptions.

Our perspective also has an advantage over much of the extant TCE literature. Williamson (1985: 366) and Riordan and Williamson (1985) claim that organization choice should be made with reference to minimizing the sum of production and transaction costs; however, much of the extant TCE literature has focused on minimization of governance costs alone. The focus on KMP adoption pays attention to making organizational choices that minimize the sum of production and transaction costs, with respect to knowledge creation and transfer. Adopting KMPs reflects economizing on bounded rationality and is analogous to choosing the lowest-cost production technology.

Additionally, numerous scholars have attacked the TCE perspective for focusing on cost reduction instead of value creation (eg., Connor 1991: 139; Zajac & Olsen, 1993). By identifying and describing knowledge attributes of transactions, this work extends the “traditional” question of “Why are certain governance modes chosen?” and provides a clear link into why actors enter into transactions in the first place. Actors enter into potentially problematic knowledge sharing relations to enhance economic rents by acquiring needed knowledge or to solve complex problems that create value. However, these exchanges give rise to costly knowledge transfer, characterized by knowledge tacitness and problem solving complexity, for which the adoption of

knowledge-management practices reduces transfer costs but generate contracting hazards. Potential behavioral problems are mitigated through the use of efficacious, safeguards in the form of governance mechanism choices. Thus, our extension provides a more complete picture of value creation and cost minimization associated with an exchange and contributes to the problem solving perspective described by Nickerson and Zenger (2001).

Our treatment of knowledge attributes of transactions is far from exhaustive. The perspective proposed herein awaits more formal theoretical development and begs empirical examination. Also, we have not developed a more general theory that considers both knowledge transfer and knowledge substitution effects with governance choice (for example, see Nickerson & Zenger, 2001). It also is important to acknowledge that other aspects of knowledge, including for example, firm technological capabilities (Behrman & Wallender, 1976; Teece, 1977; Nelson & Winter, 1982; Winter, 1988), absorptive capacity (Cohen & Levinthal, 1990) and prior experience with same partners in knowledge transfer (Gulati, 1995; Gulati & Singh, 1999) have been shown or imputed to impact the cost of knowledge transfer. While these factors are undoubtedly important, they reflect firm-specific attributes and are not presently addressed. Additionally, in contributing usefully to this discussion, Oxley (1997) does not detect even one significant firm-level factor that influences governance choice, which supports TCE's unrelenting focus on the transaction as the unit of analysis. Future research, however, should consider these firm-specific attributes as exogenous shift parameters, which may differentially affect communication costs, governance costs, or both under governance alternatives. For instance, a recipient firm possessing a high level of absorptive capacity (Cohen & Levinthal, 1990) may either lower the cost of knowledge transfer via knowledge management practices or allow for the use of low-cost, low-bandwidth interactions. However, the same firm with a high

level of absorptive capacity may engage in knowledge predation by over-accumulating knowledge from a transmitter, which increases appropriability concerns. The effects of these firm-specific knowledge factors on both knowledge-management practices and governance choice await future investigation.

Other important properties of knowledge transfer can be incorporated into the view proposed herein but have not been considered. For instance, knowledge dispersion, knowledge ambiguity (uncertainty over precisely what knowledge is needed), knowledge retrieval (including the potential for knowledge decay over time), as well as knowledge distortion, supplantation (replacement of old knowledge by new), and redundancy may influence the choices of KMPs and governance. These properties of knowledge may engender as yet unidentified knowledge-management practices, which, in turn, have governance choice implications.

5. Conclusion

This paper argued that knowledge transfer attributes, based on characteristics of knowledge to be transferred in an exchange, act indirectly, but within a plausible set of relations, on governance choice. Instead of influencing governance choice directly, a transaction's knowledge-attributes influence the choice of knowledge-management practices, which economize on the cognitive limitations of actors. The adoption of knowledge-management practices increases knowledge transparency for partners, but additionally engenders contracting hazards with accompanying governance choice implications. The paper partially resolves the aforementioned debate because it observes that the empirical observations of KBV and theoretical predictions of TCE are not at odds once transactions are more completely specified with respect to knowledge transfer attributes. Indeed, the paper shows that Kogut & Zander's

(1993) empirical observation that firms are faster and more efficient than markets at transferring knowledge can be explained by TCE when the cognitive limitations of man and knowledge transfer costs are more fully considered. Exploring knowledge transaction attributes and knowledge management practices to incorporate knowledge-related conditions of the exchange provides a more powerful lens for explaining governance choice than either KBV or TCE alone.

References

- Arrow, K., **Information and Economic Behavior**, Stockholm, Federation of Swedish Industries, 28, Reprint of Nobel prize paper, 1973.
- Arrow, K. J., **The Limits of Organization**. New York: Norton & Co., 1974.
- Behrman, J. N. and H. W. Wallender, **Transfers of manufacturing technology within multinational enterprises**. Cambridge, MA: Ballinger Pub. Co., 1976.
- Borys, B. and D. B. Jemison, "Hybrid Arrangements as Strategic Alliances: Theoretical Issues in Organizational Combinations," **Academy of Management Review**, 1989,14(2), 234-249.
- Cohen, W. M. and D. A. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation.," **Administrative Science Quarterly**, 1990, 35, 569-596.
- Conner, K. R., "A Historical Comparison of Resource-Based Theory and Five Schools of Thought Within Industrial Organization Economics: Do We Have a New Theory of the Firm?" **Journal of Management**, 1991, 17(1), 121-154.
- Conner, K. R. and C. K. Prahalad, "A resource-based theory of the firm: Knowledge versus opportunism," **Organization Science**, 1996, 7(5), 477-501.
- Daft, R. L. and R. H. Lengel, "Information richness: A new approach to managerial behavior and organizational design," **Research in Organizational Behavior**, 1984, 6, 191-233.
- Daft, R. L. and R. H. Lengel, "Organizational Information Requirements, Media Richness and Structural Design," **Management Science**, 1986, 32(5), 554-571.
- Daft, R. L., R. H. Lengel, et al., "Message Equivocality, Media Selection, and Manager Performance: Implications for Information Systems," **MIS Quarterly**, 1987, 11(3), 355-366.
- Flemming, L. and O. Sorenson, "Technology as a complex adaptive system: evidence from patent data," **Research Policy**, 2000, 1258, 1-21.
- Foss, Nicolai J., "Knowledge-based approaches to the theory of the firm: Some critical comments," **Organization Science**, 1996a, 7(5), 470-476.
- Foss, Nicolai J., "More critical comments on knowledge-based theories of the firm," **Organization Science**, 1996b, 7(5), 519-523.
- Galbraith J.R., "Organization design: An information processing view," **Interfaces**, 1974, 4, 28-36.

- Granovetter, M., "Economic Action and Social Structure: The Problem of Embeddedness," **American Journal of Sociology**, November 1985, 91, 481-510.
- Gulati, R., "Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances," **Academy of Management Journal**, 1995, 38(1), 85-112.
- Hamel, G., Y.L. Doz, and C.K. Prahalad, "Collaborate with your competitors – and win," **Harvard Business Review**, 1989, 67(1), 133-140.
- Hayek, F. "The Use of Knowledge in Society," **American Economic Review**, September 1945, 35, 519-530.
- Heiman, B., "Knowledge attributes and governance of transactions: An empirical study." Dissertation, UC Berkeley, **Haas School of Business**, 2001.
- Kogut, B. and U. Zander, "Knowledge of the firm, combinative capabilities and the replication of technology," **Organization Science**, August 1992, 3, 383-397.
- Kogut, B. and U. Zander, "Knowledge of the firm and the evolutionary theory of the multinational corporation," **Journal of International Business Studies**, 1993, 24(4), 625-645.
- Kogut, B. and U. Zander, "What firms do? Coordination, identity, and learning," **Organization Science**, 1996, 7(5), 502-518.
- Madhok, A., "The organization of economic activity: Transaction costs, firm capabilities, and the nature of governance," **Organization Science**, 1996, 7(5), 577-590.
- Nelson, R. R. and S. G. Winter . **An Evolutionary Theory of Economic Change**. Cambridge: Belknap Press, 1982.
- Nickerson, J. and T. Zenger, "A Knowledge-based Theory of Governance Choice," **John M. Olin School of Business Working paper**, 2001.
- Oxley, J., Dissertation, University of Michigan Working Paper, 1995.
- Oxley, J., "Appropriability hazards and governance in strategic alliances: A transaction cost approach," **Journal of Law Economics and Organization**, 1997, 13(2), 387-409.
- Penrose, E. T., **The theory of the growth of the firm**. Oxford: Blackwell, 1959.
- Polanyi, M., **Personal Knowledge**. Chicago: University of Chicago Press, 1962.
- Radner, R., "Hierarchy: The Economics of Managing," **Journal of Economic Literature**, September 1992, 30, 1382-1415.
- Riordan, M. H. and O. E. Williamson, "Asset Specificity and Economic Organization," **International Journal of Industrial Organization**, 1985, 3, 365-378.

- Shuen, A., "Technology Sourcing and Learning in the Semiconductor Industry," Dissertation, UC Berkeley, **Haas School of Business**, 1993.
- Simon, H. A. (1945) **Administrative Behavior**. New York, The Free Press, 1945.
- Simon, H. A., "The Architecture of Complexity," **Proceedings of the American Philosophical Society**, 1962, 106(6), 467-82.
- Simonin, B. L. "Ambiguity and the process of knowledge transfer in strategic alliances," **Strategic Management Journal**, 1999, 20(7), 595-623.
- Smith, A., **An Inquiry into the Nature and Causes of The Wealth of Nations**. Chicago: University of Chicago Press, 1976.
- Speier C., J.S. Valacich, and I. Vessey, "The influence of task interruption on individual decision making: An information overload perspective," **Decision Sciences**, 1999, 30(2), 337-360.
- Taylor, F., W., **The Principles of Scientific Management**. New York: Harper & Brothers, 1911.
- Teece, D., "'Time-Cost Tradeoffs - Elasticity Estimates and Determinants for International Technology Transfer Projects," **Management Science**, 1977, 23(8), 830-837.
- Teece, D. J., "The Market for Know-How and the Efficient International Transfer of Technology," **Annals of the Academy of Political and Social Science**, November 1981, 81-96.
- Teece, D. J., "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy," **Research Policy**, December 1986, 15, 285-305.
- Van den Bulte, C. and R. K. Moenaert, "The effects of R&D team co-location on communication patterns among R&D, marketing and manufacturing," **Management Science**, November 1998, 44(11), Part 2, S1-S18.
- Van de Ven A.H., Delbecq A.L. and Koenig R., "Determinants of coordination modes within organization," **American Sociological Review**, 1976, 41, 322-338.
- von Hippel, E., "'Sticky information' and the locus of problem solving: Implications for Innovation," **Management Science**, 1994, 40(4), 429-438.
- Williamson, O. E., **Markets and Hierarchies: Analysis and Antitrust Implications**. New York: Free Press, 1975.
- Williamson, O. E., **The Economic Institutions of Capitalism**. New York: Free Press, 1985.
- Williamson, O. E., "Comparative economic organization: The analysis of discrete structural alternatives," **Administrative Science Quarterly**, June 1991, 36, 269-296.

Williamson, O. E., **The Mechanisms of Governance**. New York: Oxford University Press, 1996.

Winter, S., "On Coase, Competence and the Corporation," **Journal of Law, Economics, and Organization**, 1988, 4(1), 163-180.

Zajac, E. J. and C. P. Olsen, "From Transaction Cost to Transaction Value Analysis: Implications for the Study of Interorganizational Strategies," **Journal of Management Studies**, January 1993, 131-145.

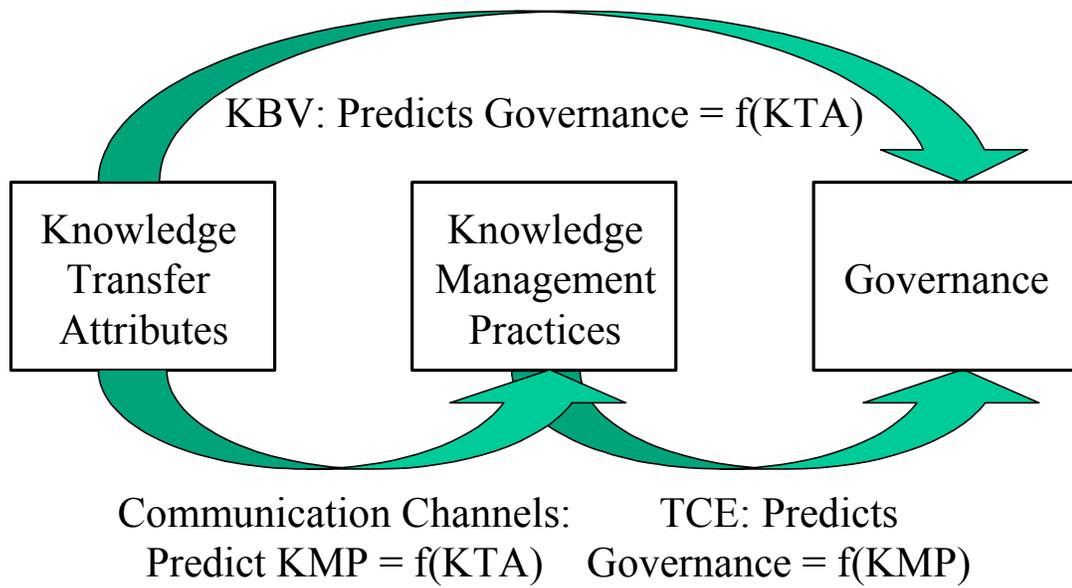


Figure 1: From Knowledge Attributes to Governance