THE PROBLEM SOLVING PERSPECTIVE: A STRATEGIC APPROACH TO UNDERSTANDING ENVIRONMENT AND ORGANIZATION

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1. INTRODUCTION

An important question facing business scholars is whether and how organizations may best adapt their investments, resource profiles, and strategies to the demands of their particular environments. While a broad literature describes organizational design principles that may assist in this regard, more recent work builds on Kauffman's (1993) NK model of biological evolution to explore how selection mechanisms and adaptive principles promote firms' exploitation and exploration efforts. This research stream has made contributions regarding the importance and efficacy of various internal adaptive factors in particular environmental settings. For instance, Levinthal (1997) shows that, despite extensive adaptation efforts, the influence of imprinting persists in complex environments with many local peaks. Rivkin (2000) demonstrates that NK complexity degrades the efficacy of search, compelling imitators to rely on search heuristics rather than

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adaptation via local learning. Rivkin and Siggelkow (2003) explore the tradeoffs between exploration and stability, and describe how particular organizational attributes, such as vertical hierarchy and group- or firm-level incentive systems, influence the flow of information throughout the organization. These as well as other contributions have added precision to the conceptualization of environments and sharpened understanding of organization by describing precisely how interdependencies across investment choices and/or resource profiles affect adaptation efforts.

While the NK literature stream provides important insights regarding the use and efficacy of particular adaptation efforts, it has yet to provide a systematic assessment of the interorganizational governance implications associated with these efforts. Beyond exhortations to engage in heuristic or local search in settings that are more or less complex, this research is somewhat unclear on whether or how particular organizational approaches facilitate different types of search. Moreover, interorganizational search mechanisms, including R&D agreements, sourcing contracts, and equity alliances and joint ventures, have not been articulated sufficiently in the NK literature. The increasing use of these alternative organizational arrangements amplifies the need to better understand their effectiveness not only in developing new knowledge, but also in protecting new knowledge. In addition to articulating the mechanisms through which different organizational forms facilitate particular types of search, it becomes necessary to understand whether and how particular search mechanisms and approaches address potential exchange hazards.

This chapter offers one way to appraise systematically the efficacy of particular organizational mechanisms in more or less complex environmental landscapes. Our approach links research in NK modeling with research that distinguishes categories of organizational forms that offer particular control and coordination mechanisms (Williamson, 1991). We specifically link NK modeling with research that suggests particular exchange hazards (Williamson, 1991) and problem difficulties (Nickerson & Zenger, 2004) can be mitigated via coordination and control mechanisms. In so doing, we propose that it is fruitful to characterize the antecedent characteristics that create search and transaction costs, as well as to dimensionalize the organizational attributes that help to mitigate these costs. In our approach, we rely on discrete comparative analysis to describe whether and when specific organizational approaches are best suited to solve challenges associated with particular environment contexts. We argue conceptually that firms balance opportunism and problem difficulty considerations by choosing an organizational approach that provides the right "mix" of control and coordination.

Our analyses suggest two promising avenues for future conceptual, theoretical, and empirical research. First, our arguments suggest that exchange impediments due to opportunism and coordination challenges due to problem complexity and structure *jointly* affect organizational form selection and subsequent performance. In describing this joint effect, we reveal an important but relatively poorly understood tradeoff between mechanisms that improve control and those that improve coordination. Whereas some interorganizational arrangements, such as shared licensing or equity partnerships, offer greater incentive alignment and monitoring or bilateral investment levels that help to mitigate moral hazard and hold-up concerns, they may not provide sufficient coordination in comparison to other interorganizational arrangements, such as codevelopment agreements or joint ventures (Leiblein & Macher, 2009). However, such coordination provisions are often necessary in order to achieve desired levels of performance; much in the same way that certain control provisions are often necessary in other contexts. Second, our arguments suggest a means to better disaggregate arrangements that have heretofore been lumped together in the ''swollen middle'' of hybrid organizational forms (Hennart, 1993). Our refined categorization suggests that circumstances exist wherein the arrangement dictated by control and/or monitoring may inhibit coordination and learning (and vice versa) and therefore lead to substandard performance.

The rest of this chapter is organized as follows. Section 2 sets the theoretical context by reviewing insights from the organization theory (OT) and NK modeling literatures. Section 3 lays out the framework of the problem solving perspective (PSP). This section first characterizes problems by their degree of structure and complexity, and organizations by their support for particular methods of solution search. It then presents a discriminating alignment argument between the characteristics of problems and the instruments available in different organizational arrangements to most efficiently solve them, paying particular attention to interorganizational arrangements such as codevelopment agreements, equity partnerships, and joint ventures. Section 4 presents several theoretical and empirical applications of the PSP. Section 5 makes several suggestions for further conceptual, theoretical, and empirical research. Section 6 provides a short conclusion.

2. THEORETICAL BACKGROUND

A substantial body of theoretical and empirical research examines the causes and consequences associated with the choice of particular organizational

forms. While it is difficult to simplify this broad literature into distinct categories, it is important to note that a large literature in transaction cost economics (TCE) emphasizes the extent to which different organizational forms solve control and coordination problems due to particular exchange characteristics (Klein, Crawford, & Alchian, 1978; Williamson, 1975, 1985, 1996). A similarly extensive literature in OT, however, attributes coordination problems to a lack of shared understanding regarding the manner in which individuals' actions are related to those of others (Thompson, 1967). Contemporary research that applies NK modeling techniques to organizational decision-making may be seen as a revival and extension of this latter work.

A defining characteristic of OT research is its focus on the identification and coordination of critical tasks through organizational structure and control mechanisms. In particular, Lawrence and Lorsch (1967) discuss the need to buffer the technical core of an organization from environmental uncertainty, and emphasize the importance of matching the level of environmental uncertainty with organizational structure and elements of organizational differentiation, such as goal, time, and interpersonal orientation. Thompson (1967) identifies differences between sequential, pooled, and reciprocal task interdependence, and similarly specifies organizational structure and control mechanisms to resolve potential coordination problems. The main point in this and other related OT research is that the underlying pattern of task interdependence defines appropriate organization.

This logic has been revised recently in a number of prominent discussions that explore the nature of search in and adaptation to particular environments. The contemporary reinterpretation of this logic draws predominantly on Kauffman's (1993) NK model to analyze associations between environmental complexity, choice, and performance. In Kauffman's (1993) original NK model, the complexity of the environment (i.e., the fitness landscape) is the direct result of assumed interdependencies among a series of attributes or choices. The N and K parameters account for this complexity, with N representing the number of available attributes or choices and K representing the degree to which the fitness landscape depends on interactions between these N components. While the NK model does not provide a specific interdependency structure, the N and K parameter values dictate the nature and shape of the fitness landscape and directly affect the marginal payoff to firms operating in the landscape.

Extant OT research utilizes the NK model as a metaphor to explore whether and how an organization with particular attributes is able to associate itself with an attractive position within a fitness landscape. In general, these

approaches describe N and K, respectively, as the number and interdependence of organizational choices or "strategic" attributes, while the fitness landscape is used to indicate the performance or survival propensity of an organization with a given set of attributes or choices (Levinthal, 1997). While differences across particular applications exist, three basic assumptions are most common. First, organizations that vary in their activity choices achieve different levels of performance. Second, organizational decision makers are boundedly rationale profit seekers. And third, the initial attributes of de novo organizations are either randomly assigned or designed to be modifications of those held by incumbent organizations. While organizations attempt to identify and implement decisions that move them to more attractive positions (i.e., more profitable, greater chance of survival, etc.) in the fitness landscape, their ability to judge the attractiveness of alternative attribute or choice profiles is both imperfect and diminishing with distance.

Most NK modeling applications do allow organizations to modify their fitness landscape positions through selection and adaptation. Selection effects occur as firms with "superior" bundles of attributes are free to enter the fitness landscape, while those with "inferior" bundles are (eventually) forced to exit. Adaptation effects occur as firms identify and modify their existing attribute bundles (Levinthal, 1997). These adaptations arise as organizations attempt to improve their performance through search efforts aimed at identifying superior attribute combinations, as well as other efforts targeted at altering their existing attribute profiles. Lacking knowledge of the entire landscape, however, some organizations may gravitate to "sticking points" where there are either no superior alternatives within the search radius or "local peaks" such that marginal changes in any one attribute diminishes performance (Levinthal, 1997). Performance variation thus occurs as organizations differ in the attractiveness of their initial location, the magnitude and type of their search efforts, and their expected adaptation costs.

The ability to clearly define complexity and to precisely delineate adaptation mechanisms helps to clarify the association between particular adaptive principles and fitness in more or less complex environments. In so doing, this work provides insights regarding the tradeoffs between information availability, coordination challenges, and exploration of alternative configurations. Different search techniques – ranging on a continuum from local, incremental search to distal, heuristic search – lead to the identification of different expectations regarding desired attribute sets. The utility of the expectations generated by these different search techniques varies with the complexity of the environment. In particular, the NK model suggests that the

efficacy of search is dependent on both an organization's current fitness value and the complexity of the landscape (Levinthal, 1997). Perhaps not surprisingly, complexity degrades the efficacy of local search by inhibiting the identification of global optima and increasing the likelihood of conflicting constraints across choices (Rivkin, 2000).[1] As a result, the marginal efficacy of search based on problem solving heuristics is greatest in more complex environments but least effective in less complex environments (Gavetti & Levinthal, 2000).

In addition to pointing out the utility of particular search mechanisms in specific environmental settings, NK techniques have also been used, albeit limitedly, to link particular elements of organizational form to specific search mechanisms. The basic insight provided in this approach relates those attributes of organizational design that facilitate adaptation. For instance, in their examination of the use of vertical hierarchy, incentive systems, and organizational structure to decompose decisions, Rivkin and Siggelkow suggest it is "specific elements of organizational design that drive a firm toward broad search and others that encourage stability" in operations (2003, p. 291) and that "an active vertical hierarchy tends to be more valuable when interactions among decisions are pervasive … however, this benefit arises only if the information flow is rich" (2003, p. 292). By manipulating the nature of interdependencies, an organization may emphasize particular interactions in an effort to stimulate the development of particular product interactions (Levinthal & Warglien, 1999, p. 343). In this and related work, the emphasis is on those attributes of product and organizational design that may be used to create interdependencies – and through these interdependencies indirectly lead individuals to "appropriate" behavior.

The recent NK literature has made significant contributions to understanding the role of search and adaptation in more and less complex environments. In particular, it has brought precision to the concept of complexity and provided important insights regarding the efficacy of local and heuristic search in various landscapes. As with all simulations, the assumptions in the underlying model may or may not accurately represent the actual environment. NK simulations assume that two factors – complexity and interdependence – define the environment in a mathematically prescribed manner. While there are reasons for believing that these two factors significantly affect the efficacy of different search techniques, these two factors may or may not provide a collectively exhaustive definition of the landscape. Similarly, simulation research applying the NK model assumes that particular adaptation or selection mechanisms affect firms'

abilities to identify attractive positions on the landscape. While particular mechanisms discussed in any model may affect information flow, NK modelers have yet provided guidance regarding the specific attributes that "dimensionalize" governance forms.

While recent efforts have emphasized intra-organizational search, NK research has yet to examine factors associated with interorganizational search. Once interorganizational issues are considered, however, problems of opportunism and exchange hazards rise to the surface. The potential for significant interactions to exist across organizational boundaries that employ different incentive systems, sanctioning opportunities, and control and coordination methods suggests that additional and interesting insights may be obtained by extending the search context outside of an intra-organizational setting.

3. THE PROBLEM SOLVING PERSPECTIVE

3.1. Problem Types

Strategy research generally requires a means not only to identify, categorize, and "dimensionalize" the important attributes of particular organizational forms, but also to relate these organizational forms to environmental conditions where they are particularly suited. Nickerson and Zenger (2004) propose a theory of the firm based on the problem solving and solution search efficiencies of alternative organizational modes (see also (Hsieh, Nickerson, & Zenger, 2007; Macher, 2006). These authors build off of earlier NK research as well as the knowledge-based view (KBV) (Conner & Prahalad, 1996; Grant, 1996; Kogut & Zander, 1992, 1996) to provide theoretical and empirical discriminating alignment arguments between problems, which vary according to their structure and complexity, and organizational modes, which vary according to their abilities to support knowledge development and transfer. The efficiency of organizations in these activities typically entails the development of and/or access to information, resources, and assets that exists both within and outside of firm boundaries.

This research not surprisingly emphasizes organization as a mechanism to reduce cognitive and coordinative problems. This work also notes that knowledge development and transfer problems vary significantly with the nature of the knowledge that needs to be coordinated and the importance of organization in these efforts. For instance, Nonaka (1994) emphasizes the

conversion of tacit into articulated knowledge is difficult, while Nonaka and Takeuchi (1995) suggest the importance of coordinating tacit knowledge in the firm's role as knowledge creator. Grant (1996) similarly focuses on the role of organization in transforming different forms of knowledge (e.g., subjective vs. objective knowledge, implicit or tacit vs. explicit knowledge, personal vs. prepositional knowledge, and procedural vs. declarative knowledge) into productive outputs.

Building off of these suggestions, the "problem solving perspective" introduces a categorization of problem types that may be mapped to particular organizational solutions, while also taking the environment context into consideration. In a manner similar to NK research that describes the environmental landscape (Levinthal, 1997), the PSP describes problems as systems that correspond to sets of decisions that differ systematically according to their structure and complexity (Fernandes & Simon, 1999).

Given the differences in characteristics of the problem domain on the one hand and the availability of problem solving mechanisms on the other, problems are conceptualized as varying on a continuum from ill structured to well structured (Fernandes & Simon, 1999; Simon, 1973). Ill-structured problems have poorly-defined initial states (N and K are equivocal) and AU :4 unexpected and/or unknown knowledge set interactions. By contrast, well-structured problems are those with well-defined initial states (the N and K parameters discussed above are unequivocal) and well-understood knowledge set interactions that define how the individual knowledge components vary across time and space. Ill-structured problems have poorly-defined initial states (N and K are equivocal) and ambiguous problem solving approaches, while well-structured problems are those with well-defined initial states (N and K are unequivocal) and explicit problem solving approaches. Moreover, ill-structured problems have unexpected and/or unknown knowledge set interactions, while well-structured problems have well-understood knowledge set interactions (Levinthal, 1997).

Problem complexity varies with the number of knowledge sets for a given problem (N) and the magnitude (K) or degree of interdependence among these knowledge sets. In other words, problem complexity represents the number of issues, functions, or variables involved and the degree of relationship among these properties. Given the level of knowledge set interactions, problems similarly vary on a continuum from simple to complex. Simple problems are also composed of fewer variables which interact in more predictable ways. By contrast, complex (e.g., nondecomposable or high-interaction) problems entail extensive knowledge set interaction (Nickerson & Zenger, 2004), have high intransparency (i.e.,

only some variables lend themselves to direct observation or the large number of variables requires selection of the relevant few), and have significant connectivity between variables (Funke, 1991). Complex problems require the balancing of multiple variables during problem structuring and solution search, which places significant cognitive burdens on problem solvers (Jonassen, 2004). These types of problems also differ in their level of decomposability (Ethiraj & Levinthal, 2004). Simple (e.g., decomposable or low-interaction) problems have solutions that depend little on the interaction of knowledge sets and can readily be subdivided into subproblems that draw on these different knowledge sets, while complex (e.g., nondecomposable or high-interaction) problems have solutions with significant knowledge set interactions and cannot be easily subdivided.[2]

As mentioned, the structure and complexity of problems lie on respective continuums (i.e., from well structured on one side to ill structured on the other; from simple on one side to complex on the other). We make the illustrative argument that "moderately-structured" problems lie somewhere along the continuum between the poles of ill structured and well structured. These types of problems might be best characterized by some knowledge set interactions being well understood while others are not. Similarly, moderately complex problems lie somewhere along the continuum between the poles of simple and complex. These types of problems might be considered nearly decomposable, whereby patterns of interaction among choices are clustered into identifiable modules (Nickerson & Zenger, 2004). We discuss the organizational implications of such a construct as follows.

The PSP borrows from the KBV to categorize organizational forms in a manner that affects how they transmit and coordinate information. The KBV aspects that are of greatest interest to the PSP emphasize differences between organizational forms in their ability to exercise authority (Conner, 1991; Conner & Prahalad, 1996; Demsetz, 1988), develop specialized communication codes and language (Arrow, 1975; Grant, 1996; Kogut & Zander, 1992, 1996; Monteverde, 1995), and leverage a shared identity (Ghoshal & Moran, 1996; Kogut & Zander, 1996). The arguments underlying this research suggest a variety of mechanisms through which organizational form affects the development and exchange of information. Conner & Prahalad (1996, p. 485) discuss how the authority relationship "allows an individual to use the knowledge of another before the former fully understands or agrees with it." Monteverde (1995) describes how specialized communication codes may be used to facilitate information transfer, integration, and learning of complex and tacit information. Kogut and Zander (1996, p. 503) state that "the shared identity that exists within a

firm lowers the cost of communication and establishes "rules of coordination and influences the direction of search and learning."

3.2. Solution Search

These categorizations of problems are important because differences in problem structure and complexity imply different solution search challenges. For instance, the defining characteristic of ill-structured problems in comparison to well-structured problems is that there is no agreed upon or formalized process or approach for solving (Fernandes & Simon, 1999). Whereas well-structured problems may be solved efficiently through explicit and well-defined problem solving approaches, problem solving approaches for ill-structured problems are ambiguous. Moreover, the interactions among knowledge sets for well-structured problems are well understood, in comparison to ill-structured problems. While this characteristic does not affect the shape of the solution landscape, it does make solution search easier and more transparent (Macher, 2006). As sufficient information is available and search strategies are well known for these types of problems, directional search guided by feedback or experiential learning provides certain efficiency benefits in finding high-value solutions. Formalized processes can more easily be put into place as knowledge sets either do not interact or interact in predictable ways. For simple problems, the magnitude of interactions is small in comparison to complex problems, suggesting that the solution landscapes are characterized as relatively "smooth." Again, directional search approaches provide certain advantages to these types of problems through experiential learning and feedback. Moreover, solution search can be subdivided and decisions made independently from each other using multiple actors engaged in examining particular knowledge sets potentially relevant to problem solving.

For complex problems, the knowledge set interactions among knowledge sets are poorly understood in comparison to simple problems. As these types of problems have unexpected and sometimes unknown knowledge set interactions, they cannot easily be subdivided due to the extent of the interdependencies. For these types of problems, solution search is more difficult as important information is unknown and formalized search strategies are either untried or untested. Search strategies that evaluate the probable consequences of particular choices and rely upon developed heuristics provide certain efficiency benefits in finding high-value solutions. For complex problems, the magnitude of knowledge set interactions is large

in comparison to simple problems, which suggests that solution landscapes are relatively "rugged." These types of problems thus require greater evaluation of the consequences of particular search decisions for efficient problem solving.

3.3. Discriminating Alignment

If the magnitude and type of coordination and control challenges vary across problem types and organizational forms provide different coordination and control support mechanisms, then it is possible that high-value solutions to particular problems may be best addressed via specific organizational approaches. As suggested above, the distinctions between ill- and well-structured problems and simple and complex problems suggest that certain solution search strategies realize performance benefits. Because ill-structured problems and complex problems are neither predictable nor convergent in approach, they benefit from ex-ante cognitive evaluations of the probable consequences of particular solution search decisions as opposed to ex-post reliance on feedback from decisions already made (Simon, 1991). Established heuristics are therefore necessary to guide and shape problem solving efforts because limited information and a general lack of understanding exist on whether different knowledge sets are (or are not) part of the solution space. Heuristic search strategies provide efficiency gains for these types of problems via a more thorough evaluation of the probable consequences of any search decision made. By contrast, well-structured and simple problems are effectively represented within a solution landscape such that all relevant knowledge sets are part of that landscape and the path to high-value solutions is clear. The solution search strategies for these problems are also known, and sufficient information is available for solving these types of problems with only practical amounts of independent search (Simon, 1973). With these fitness landscapes, directional search guided by feedback or experiential learning provides efficiency gains in achieving high-value solutions in comparison to heuristic search.

Markets should realize performance advantages in finding solutions to well-structured and simple problems due to their superior abilities to facilitate directional search. Markets offer high-powered incentives, decentralized control, and mechanisms that allow individual actors to exploit and enhance their own specialized knowledge. Price acts as a high-powered incentive that motivates actors to develop this specialized knowledge (Hayek, 1945). Markets also face more acute competitive pressures that reduce organizational slack and increase incentives to operate efficiently (D'Aveni &

Ravenscraft, 1994), and are more responsive in adapting to technical or environmental uncertainty (Williamson, 1985). Because the fitness landscapes are smooth and the problem solving approaches are understood for well-structured and simple problems, economic actors can operate independently in search of high-value solutions. Hierarchies are comparatively disadvantaged in finding high-value solutions for these types of problems. These organizational modes facilitate knowledge sharing and transfer, but well-structured and simple problems neither require nor benefit from these features. Moreover, the low-powered incentives, more generic knowledge sets, and bureaucratic features of hierarchies only add costs by moderating the speed and efficiency with which potential solutions can be examined.

While markets better navigate solution landscapes for well-structured and simple problems, they face challenges as problems become ill structured or complex. Because the approach to solving these types of problems has not been fully formalized, greater control and/or coordination is necessary among economic actors to develop and prioritize search strategies that are likely to yield high-value solutions. Internal organization is comparatively advantaged in finding solutions for these types of problems, as their firm-specific languages, communication codes, and information channels, combined with their low-powered incentives and dispute resolution mechanisms, encourage knowledge sharing and promote coordination (Grant, 1996; Kogut & Zander, 1992, 1996; Monteverde, 1995). The formation of research and development goals and the definition of research agendas are also easier under hierarchies (Armour & Teece, 1980), which are likely activities when examining ill-structured problems.

Moreover, for problems of moderate structure or moderate complexity, particular hybrid (alliance) arrangements can be implemented that might achieve efficiency benefits in finding high-value solutions superior to those of either markets or internal organization, given the solution search features (i.e., levels of incentive intensity, control, and coordination) available in these organizational approaches. Table 1 provides an overview of our discriminating alignment argument related to problems, solution search, and performance. This table suggests that problems, which vary according to their structure and complexity, should be matched to appropriate organizational modes, which vary according to their abilities to effectively support solution search, in order for firms to efficiently realize high-value solutions.

Per the above discussion, we suggest further that organizational forms vary not only in terms of their abilities to protect against appropriability hazards, but also in their solution search efficiency benefits depending upon the characteristics of problems. For instance, in much the same way that markets

Table 1. Problems and Alternative Organizational Modes.

	Market	Hybrid (Alliance)	Internal Organization
Instruments			
Incentive intensity	++	+	0
Control	0	+	++
Coordination	0	+	++
Search			
Directional search	++	+	0
Heuristic search	0	+	++
Performance			
Ill-structured problem solving	0	+	++
Complex problem solving	0	+	++

++ Strong; + semistrong; 0 weak

Source: Adapted from Nickerson and Zenger (2004). AU :1

vary from internal organization, alliance arrangements vary in their ability to support specific investment, information transfer, and particular types of search behavior. Traditional cash- and license-based agreements arguably serve as the base case and approximate something closest to markets. These alliance arrangements offer relatively limited abilities to direct problem solving activity, as they provide somewhat limited communication and relatively infrequent contact among alliance partners. Codevelopment agreements more likely provide enhanced coordination through frequent but not usually permanent interactions between resources, but do not offer substantial control over the alliance arrangement or specific alliance partners. Equity partnerships, by contrast, might provide higher levels of authoritative control and monitoring, but coordination is often limited to interactions between professional managers and board members as opposed to line-level personnel. Finally, joint ventures are most likely to provide superior coordination and substantial knowledge transfer through negotiations between parent firms, exchange of information between board members, as well as the pooling of information among human resource personnel.

Given the greater control provided, equity partnerships and joint ventures provide greater authority in either directing solution search or forcing coordination between and among market specialists in ways that cash- and license-based alliances and codevelopment agreements cannot. These types of alliances might approximate Nickerson and Zenger's (2004) authority-based hierarchy in a hybrid organizational form. Given the greater coordination, codevelopment agreements and joint ventures arguably better

Table 2. Alliance Arrangements and Problem Solving.

		Degree of Control	
		Low	High
Degree of coordination	Low	Cash- or license-based alliance	Equity partnership
	High	Codevelopment agreement	Joint venture

facilitate the development and exchange of information necessary for heuristic search in ways that cash- and license-based alliances and equity partnerships cannot. These types of alliances might approximate Nickerson and Zenger's (2004) consensus-based hierarchy in a hybrid organizational form. Note importantly that joint ventures provide both authoritative control important for directional search and communication important for heuristic search, in comparison to other alliance arrangement alternatives. These alliance types might therefore be best able to manage the knowledge set interdependencies that exist in solving increasingly ill-structured or complex problems in comparison to markets, but perhaps not for the "most" ill-structured or complex problems in comparison to hierarchies. Table 2 summarizes these alliance arrangements archetypes according to the mechanisms described earlier. AU :5

We now turn to applications of the PSP, providing examples at a number of different organizational levels and from a number of different industry settings. While we highlight just a few of these examples below, we note here that much more conceptual, theoretical, and empirical research is required in unpacking this perspective.

4. APPLICATIONS

4.1. Internal Vs. Outsourcing Decisions

A fundamental question in strategic management is how firm organization affects performance. Two approaches that have been seen considerable examination are internal versus external sourcing (e.g., vertical integration) decisions and alliance arrangements. We argue that both organizational approaches can usefully be thought of as a new business model, given each addresses "the way the firm operates." Moreover, both approaches can and have been usefully addressed through the PSP. We examine outsourcing decisions in this subsection and alliance arrangements in the next. AU :6

Two recent empirical papers apply the PSP to outsourcing decisions. Macher (2006) utilizes the PSP in an examination of how semiconductor firms organize efficiently to solve complex and ill-structured problems related to new manufacturing process development. Problem structure is operationalized according to the semiconductor product manufactured,[3] while problem complexity is operationalized according to the proximity of the semiconductor manufacturing process to the leading edge.[4] Distinct performance differences in problem solving important for technological development are found between firms specialized in semiconductor manufacturing and those integrated in product design and semiconductor manufacturing. Integrated device manufacturers (IDMs) achieve performance advantages in terms of the speed and effectiveness of new manufacturing process development when development entails complex problem solving. Integrated firms are more effective in solving these types of problems because their communication structures and organizational mechanisms facilitate heuristic search through authority or consensus-building. At the same time, specialized manufacturers (so-called foundries) realize performance advantages when technological development involves well-structured and simple problems. Market modes of organization improve both the speed and quality of problem solving through directional search due to their high-powered incentives and specialized expertise.

Macher and Boerner (2008) utilize the PSP in a similar examination of how pharmaceutical firms organize efficiently to solve ill-structured and complex problems in drug development. The performance of pharmaceutical firms integrated in drug discovery and drug development are compared against pharmaceutical firms concentrated in drug development (so-called contract research organizations, or CROs). The calendar time required for a drug compound to complete the clinical trial process (i.e., from Investigational New Drug (IND) submission through New Drug Application (NDA) submission) serves as the performance measure. Problem structure represents the degree to which clinical information of a drug compound is disseminated across the industry,[5] while problem complexity represents a measure of the magnitude to which information sources necessary in conducting clinical trials are spread across the clinical trial.[6] The empirical results indicate that firms improve performance from outsourcing when technological development entails well-structured and simple problems – given the benefits of specialized knowledge development resources available in the market and the ease of knowledge transfer – and improve performance via internal approaches when development entails ill-structured and complex problems – given the knowledge integration resources

within firms and the difficulty of knowledge transfer. Moreover, pharmaceutical firms' technological area experience is also found to improve knowledge development within firms through experiential learning-by-doing, and facilitates knowledge transfer between firms through improved selection, monitoring, and communication. Arguably the most interesting finding, however, is the interplay found among the structure of problems, the choice of organization, and the depth of technological area experience. While technological area experience improves performance regardless of organizational approach, the difficulties associated with developing and integrating knowledge across firm boundaries rather than within firm boundaries become especially acute when technological development problems are sufficiently ill structured.

4.2. Alliance Arrangement Decisions

Alliances are another important organizational approach that many firms utilize toward creating and sustaining competitive advantage. These organizational approaches can also be usefully thought of as the development and implementation of a new business model, in that they suggest ways in which improvements can be made to firms such that they operate more efficiently.

Heiman and Nickerson (2004) examine empirically the effects that problem complexity has on alliance arrangement decisions, using the Cooperative Agreements and Technology Indicators (CATI) database. Their sample frame represents the population of all publicly-announced alliances between 1977 and 1989. The decision by firms to use joint-equity ownership via joint ventures is compared against the use of unilateral nonequity arrangements via customer–supplier partnerships, licensing, and other contracting arrangements. Problem complexity is measured as an indicator of whether new, valuable, and strategic knowledge is expected to result from combining the distinct collaborator-contributed knowledge of the alliance partners. The empirical results indicate that equity alliances are more likely as problem-solving complexity increases.

Leiblein and Macher (2009) utilize the PSP in an examination of how ownership and colocation in different alliance arrangements aid firms in meeting desired technological performance objectives. Alliance arrangements that increase common ownership help align incentives, increase monitoring, and improve managerial control, while alliance arrangements that colocate personnel improve coordination and communication between

partner firms. Utilizing both TCE and the PSP, the authors identify four distinct alliance arrangements and propose that the influence of these arrangements on performance is dependent on the nature of problem solving related to technological development. Problems are measured according to their "difficulty," which represents a composite measure of structure and complexity related to the technological development effort. The empirical setting consists of a sample of 664 alliances around production sourcing in the semiconductor industry. A polychotomous two-stage analysis is used to disentangle decisions to utilize a given alliance arrangement from the performance of that alliance arrangement. The authors find that the difficulty of technological development problems determines both the selection and technological performance of alliances.

4.3. Entrepreneurial Activities

A fundamental issue in the entrepreneurship literature is the process by which opportunities are discovered and exploited. Hsieh et al. (2007) utilize the PSP to examine when entrepreneurs should employ markets to help discover and exploit opportunities, and when entrepreneurs should create firms to do so. The authors argue that opportunities equate to valuable problem-solution pairings, and that opportunity discovery relates to searching over this solution space. As problem complexity increases, experiential search via trial and error provides fewer benefits, relative to heuristic search via theorizing. Heuristic search nevertheless requires greater knowledge sharing than experiential search when knowledge is distributed among specialists, however, and is plagued by knowledge appropriation strategic knowledge accumulation hazards. The authors argue that different organizational modes (markets, authority-based hierarchy, and consensus-based hierarchy) have differential effects on the efficiency of opportunity discovery, given the complexity of the associated opportunity discovery problem. Hsieh et al. (2007) utilize a number of qualitative entrepreneurial case studies, including the cosmetics firm Jaqua Girls, the coffee retailer Starbucks, and the kitchen utensil firm OXO International, as illustrations of their argument.

5. DISCUSSION

This chapter combines aspects of recent literature applying NK modeling techniques to examine questions of search and adaptation in smooth and

rugged competitive landscapes, along with insights derived from TCE and the PSP that associate the use of particular governance forms to issues associated with opportunism and problem difficulty. We suggest that firms' fitness landscapes differ in terms of their levels of exchange hazards and problem solving requirements. Because particular organizational forms provide different levels of control and communication, we therefore argue that a fundamental issue for firms is how to decide on organizing search by simultaneously factoring in the exchange hazards and problem solving demands associated with a particular environment along with the incentive alignment, control, and coordinative attributes associated with a specific organizational form. Our arguments suggest in particular that firms balance opportunism and problem difficulty considerations through the choice of organizational forms that provide different levels of control and communication.

Our analysis suggests at least three broad avenues for future conceptual, theoretical, and empirical research. First, future research can contribute by identifying and categorizing the critical elements of the competitive landscape and particular organizational forms. Research applying NK techniques depicts competitive landscapes in terms of complexity and interdependence (Levinthal, 1997; Rivkin & Siggelkow, 2003). TCE work argues that organizational forms principally differ in terms of incentive intensity, direction, and legal regime (Williamson, 1991). The emerging PSP suggests that organizational forms differ in terms of incentive intensity, communication channels, and dispute resolution regime (Nickerson & Zenger, 2004). We suggest that additional work is needed to verify whether these dimensions appropriately portray the competitive landscapes and organizational forms.

Productive future research may therefore examine whether and to what extent these particular dimensions represent mutually exclusive and collectively exhaustive characterizations of environment and organizational form. Such research might examine whether it is appropriate to distinguish between NK complexity and other proposed elements of the competitive landscape. In this chapter, we discuss how the concept of problem structure may contribute to our understanding of the environment. Similarly, work in industrial organization (IO) economics has described how factors such as market size, market growth, and the number and type of competitive rivals illustrate other elements of the competitive terrain. Analogous issues arise in describing and confirming the salient dimensions on which organizational forms differ. In particular, it would be worthwhile to present empirical evidence supporting a parsimonious list of mechanisms that effectively distinguish between organizational forms.

A second and direct extension of this refined categorization is the development of theory regarding the associations that exist across this set of core constructs. Research applying NK techniques has simulated how specific selection and adaptation mechanisms are more or less suited to efficiently searching over fitness landscapes that vary in their complexity and interdependence. TCE and the PSP have conceptually described how particular mechanisms (e.g., incentive intensity, direction, legal regime) associated with different organizational forms are more or less suited to adapting to exchange demands that vary in their degree of opportunism and problem structure. What appears to be needed but missing currently is research that examines whether and how the mechanisms underlying economic organization address the coordination and control problems highlighted by these two theories.

Subsequent research may contribute by examining whether and how mechanisms associated with particular organizational forms such as incentive alignment and colocation are able to address both exchange and coordinative hazards. Future theoretical research may productively develop and extend arguments that use refined categorizations of the competitive landscape and organizational form to suggest how particular elements of environment (e.g., complexity, interdependence, and problem structure) relate to specific organizational mechanisms (e.g., incentive intensity, monitoring, direction, and heuristic search). Future empirical research may contribute by observing correlations across environments and organizational forms associated with different levels of these critical elements and mechanisms. For instance, in our own research we have attempted to unbundle the effects of potential exchange hazards from the challenges of managing complex problems and proposed that particular mechanisms associated with different forms of alliance organization are better suited to solving each of these primary issues. This basic approach may be applied to examine organization in other settings. For instance, this approach may be applied usefully to international contexts to examine whether and how multinational alliance networks and multinational organizations differ in their ability to solve business problems that vary in their complexity and potential for opportunism.

Finally, it is desirable to develop theory that establishes the causality of relations between these various constructs. One means to address causality is to examine whether the effect of specific organizational mechanisms varies with the maturation of the competitive landscape. While exceptions exist, as markets and technologies evolve and industries become mature, problems tend to become less complex and increasingly well structured. These aggregate changes suggest one means to address causality is to examine

whether the effect of specific organizational mechanisms varies with the maturation of the competitive landscape. While organizational forms that support heuristic search may be useful in rugged landscapes potted with local peaks and gravity wells, and the safeguards of firm organization may be useful to support idiosyncratic, firm-specific investment in emerging competitive arenas, the efficacy of these instruments should diminish over time as landscapes smooth and rely to a greater extent on more generic assets. Future research may therefore explore usefully whether the widespread "deintegration" of industries is driven by changes in the complexity of underlying technologies and markets or by changes in the ability of organizations to efficiently coordinate activity. Alternatively, there is likely value in examining whether the efficacy of investments in internal development, alliances, and outsourcing agreements vary over the lifecycle of a product or technology.

Fig. 1 presents a conceptual model used to systematically consider these associations between the competitive landscape, organizational choice, and performance. The left panel captures aspects of the environment that affect search and adaptation such as complexity, interdependence, and problem structure. The middle panel represents dimensions of organizational forms that may be chosen by managers or selected by the environment to address the coordination and control challenges posed by the competitive environment. The right panel indicates the performance outcome that may be expected as a consequence of a particular set of decisions in a specific environment. Exemplars of potential attributes, decisions, or outcomes are listed at each stage in the figure. The solid lines suggest questions regarding the antecedents and consequences of particular managerial decisions or selection of organizational forms, while the dotted line serves as a reminder that the choice variables represented in the middle panel are not randomly

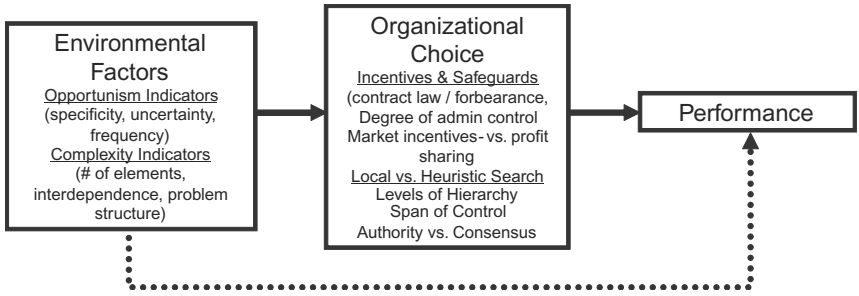

Fig. 1. Conceptual Model.

assigned and the consequences of these variables are therefore susceptible to bias.

6. CONCLUSION

We argue that the PSP has much to offer in aiding the development of a theoretical approach to understanding environment and organization. How firms organize efficiently in different environments such that superior performance is realized is central to understanding competitive advantage. The PSP redefines the unit of analysis to one that is arguably superior to those used by other organizational theories and perspectives of the firm. In particular, firms attempt to solve problems in their day-to-day business operations. Problems can further be characterized according to particular dimensions that are measurable. Moreover, this unit of analysis supports Commons's (1934, p. 4) view that "any unit of activity … must contain in itself the three principles of conflict, mutuality, and order." We suggest that the "problem" more closely reflects actual decision-making processes in practice by firms. The PSP also provides a discriminating alignment approach, whereby the particular "attributes" of the unit of analysis can not only be measured, but also be compared and contrasted against the organizational modes available such that efficient organization (lower costs, improved productivity, better performance, etc.) obtains.

We also suggest that the PSP can also be used to address several theoretical implications and practical applications at the crux of strategy research. For instance, efforts to develop new business strategies, commercialize new product and process innovations, implement new supply chain configurations, or introduce new manufacturing processes generally require the solving of problems. Some of these problems might be considered well structured and simple, while others considered more ill structured and complex.

We encourage strategy researchers to look critically at proposed theories of the firm, and consider using a problem solving approach. Many avenues of future research within the PSP present themselves. For instance, a theoretical perspective of the initial phases of the problem solving process – the strategic problem formulation – is under development (Baer, Dirks, & Nickerson, 2008), but requires empirical evaluation and validation of the proposed structured process. This chapter proposes that hybrid organizational arrangements falling between the polar modes of market and internal organization also offer unique solution search characteristics. While efforts are underway to develop and empirically test how well the problem solving

costs and competencies of different hybrid organizational arrangements vary, much more research is warranted.

NOTES

1. Rivkin (2000) analyzes three search heuristics. The incremental search heuristic allows imitating firms to consider alternative choice sets (strategies) that involve changing a prespecified subset of the N choices. The follow-the-leader heuristic allows imitating firms to consider alternative strategies that involve changing a subset of their choices so as to match those of the leader. Finally, the hybrid search heuristic allows imitating firms to alternate between the two prior search strategies.

2. Ill-structured problems tend to be more complex while well-structured problems tend to be less complex, but this is not a hard and fast rule. Problem structure represents firms' level of understanding of knowledge set interactions, while problem complexity represents the magnitude of these interactions. Well-structured problems might be complex if the K interactions are known but large in number, while ill-structured problems might be simple if the K interactions are unknown but small in number.

3. The development of manufacturing processes for analog and memory products are often described as activities based more on art than on science, given the incomplete understanding of the parameter interdependencies between product design and process manufacturing.

4. Leading-edge manufacturing processes typically introduce new materials and new manufacturing process steps, increasing the number of relevant knowledge sets in the development effort. The tasks of learning the physical limits of the manufacturing process are compounded by the need to understand the functional limits of the product design, as well as how these factors interact.

5. This variable is a measure of the number of other drug compounds under development or approved within the same drug indication (a subset of a therapeutic area) as the focal drug compound. With less pre-existing knowledge and information regarding the therapeutic characteristics of new drug compounds, firms' understanding of the knowledge sets and interactions applicable to a new drug compound are limited.

6. This variable measures complexity along two dimensions: first, the size, scale, and location of the patient and clinical site population participating in the clinical trial; and second, the administrative and scientific complexity in conducting the clinical trial. A larger number of geographically dispersed patients or clinical research sites participating in the clinical trial creates greater complexity. Clinical trials management include scientific activities (i.e., performed procedures, required observations, endpoint and protocol setting, etc.), and administrative activities (i.e., human subject protection, site management, trial quality, and data integrity).

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