Paper to be presented at the DRUID 2012

on

June 19 to June 21

at

CBS, Copenhagen, Denmark,

Hierarchical Participation Constraints for Adaptive Learning and Coordination

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Abstract

From the knowledge-based view of competence, firms exist as an institution where knowledge accumulation and knowledge application are facilitated by organizing principles that markets cannot provide. While scholars perceive that these two interdependent knowledge processes could be influenced by formal aspects of organizations, the underlying mechanisms still need to be unpacked. As such an organizing principle, we suggest in this study that hierarchical participation constraints promote both adaptive learning at the individual level and dynamic coordination at the organization level. Hierarchical participation constraints therefore provide for efficiency and adaptability in dealing with

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Abstract

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Keywords: *Coordination, Hierarchy, Knowledge, Learning, Organization Design, Specialization*

Introduction

Knowledge is regarded as the most important source of competitive advantage (Barney 1986, Grant 1996b, Kogut and Zander 1996). All human productivity is knowledge dependent, and technologies and tools are simply embodiments of knowledge. Unlike other value-creating resources (e.g., physical or financial resources), strategically important knowledge is often difficult to recognize, understand, and transfer. Such characteristics of valuable knowledge serve as an important isolating mechanism for the persistence of performance differences among competing firms (Lippman and Rumelt 1982). Knowledge-based competitive advantage therefore constitutes the core of the resource-based view of the firm (Barney 1996, Conner and Prahalad 1996, Demsetz 1973).

At the heart of such knowledge-based view of competitive advantage lies the issue of knowledge accumulation and application. The salient question here is how valuable specialist knowledge can be developed at the individual level and integrated through organizational means into organization-level capability (Foss 2007, Grant 1996a, Winter 2000). A basic tenet of the knowledge-based view literature is that firms exist as an institution where knowledge accumulation and application are facilitated by organizing principles and mechanisms that markets cannot provide (Ghoshal and Moran 1996, Grant 1996b, Kogut and Zander 1996, Spender 1996). Such knowledge processes can be influenced and directed through the formal aspects of the organizational structure that can be manipulated by management (Foss 2007, Nickerson and Zenger 2004).

Organization design efforts to promote such knowledge processes, however, encounter two fundamental challenges. First, often highlighted in research and practice, transferring knowledge is not an efficient approach to integrating specialist knowledge in timely manner (Demsetz 1988; Grant, 1996a; Nickerson & Zenger, 2004). The ability or motivation to share knowledge is impeded mainly by two conditions: humans are cognitively constrained in the speed with which they learn and they are prone to self-interest (Simon 1991, Foss 2007). Even if valuable knowledge is identified, the person who possesses such knowledge may not want to share it and/or considerable time and efforts may be needed to absorb and apply it. Although untransferability of strategically valuable knowledge constitutes the theoretical underpinning of the knowledge-based view of competence, it should be somehow overcome within the organizational boundary to gain competitive advantage from such knowledge. Crucially, full knowledge transfer is not often desirable. The whole point of gains from the division of labor is that specialists differ in what they know and what they can do (Demsetz 1997, Grant 1996a). Coordination for knowledge integration is therefore often best achieved through the direct involvement of individual specialists. Integration mechanisms such as team-based organization, however, can usually involve limited numbers of individuals (Nickerson and Zenger 2004, Epstein et al. 2010) and impose another challenge of identifying, classifying, and allocating individuals with various scopes and depth of knowledge in an efficient way.

The second, relatively less explored, issue is that knowledge accumulation can be hardly decoupled from knowledge application. Valuable knowledge is usually garnered through context-specific learning-by-doing processes. Organizational members learn from what they do and the task allocation structure is a major determinant of the knowledge accumulation process. This implies that, in dealing with various kinds of problems, the ways in which specialized members are coordinated and assigned to specific tasks shape the accumulation of knowledge which in turn influences subsequent ways and results of coordination (Kogut and Zander 1992). The true challenge of organization design from a knowledge-based perspective, therefore, roots in such inherent endogeneity between experiential learning at the individual level and knowledge integration at the organization level.

This study aims to provide a useful principle for understanding and enhancing the organization of knowledge processes. On the basis of the outlined challenges, we develop a formal model of individual learning and dynamic coordination for problem solving in an organization's decision-making process. The model assumes that an organization with a number of decision makers faces an exogenous and uncertain influx of problems and decision opportunities from the environment. A decision can be associated with a certain kind of problems which require corresponding knowledge for its resolution. The decision makers have a limited capacity but different scopes of knowledge which adapt to what they work on. The organizational structure determines who deal with what kinds of problems in the decision process. The problem-solving efficiency of the organization, therefore, depends on how to organize the participation of the decision makers which also influences experiential learning at the individual level.

The analysis based on the model suggests that a hierarchical organization of participation constraints provides an advantage of adaptive learning and coordination in environments of diverse and difficult decision problems. Under such organizational structure, some members are dedicated to fewer kinds of problems and allowed to develop narrower but deeper, more specialized knowledge,. Other members are allowed to deal with more kinds of problems and develop shallower but broader, more general knowledge. When demand for problem-solving knowledge is concentrated on a narrow scope, specialists with corresponding knowledge can efficiently handle most problems and the generalists help in problem-solving with increasing efficiency through experiential learning. When knowledge demand is spread out over a broad range, the specialists cover their range and free the generalists to deal with a reduced range of problems. This makes it easier for the generalists to adapt to changes in knowledge demand, because they need to learn less. In sum, the advantage of hierarchical participation constraint is achieved by dynamically balancing between specialization (the primary role of specialists) and coordination (the primary role of generalists).

This paper is organized as follows. In the following section, we specify model settings and behavioral assumptions. Next, we present and discuss the results from the analysis based on the model. Lastly, theoretical and empirical implications follow.

Model

The model is designed to examine the influence of organizational structure on the dynamic process of specialization and coordination in problem solving for organizational choices[1]. Given our interest in tacit knowledge and experiential learning, we make three basic assumptions with respect to environmental uncertainty and the cognitive limitation of the decision makers: (1) an organization faces decision opportunities and related problems exogenously arising from the environment, (2) different types of problems require corresponding types of knowledge for resolution (3) the organization has a fixed number of decision makers whose knowledge adapts to the problems they

[1] Our model builds on the 'garbage can model' of organizational choice (Cohen et al. 1972). It provides a formal framework to model a dynamic coordination process in which organizational structure constraints the matching between decision makers with available energy and problems requiring energy, while their movement is also guided by a predefined behavioral rule (Fioretti and Lomi 2008).

work on. The non-trivial and interesting aspect of this decision-making process is, as noted above, the interdependence between experiential learning at the individual level (knowledge accumulation) and dynamic coordination at the organizational level (knowledge application). Our focal interest lies on how the problem-solving efficiency of the organization is influenced by its organizational structure. The organizational structure constrains who encounters and learns from what problems in the decision making process and we examine the performance properties of alternative approaches to designing the organizational structure. The following subsections specify each element of the model.

Environment and Organization

An organization is represented as a collection of a given number (N) of decision makers, which operates in an environment where various kinds of decision problems and incidents for organizational choices continue to arise. We assume a finite number of problem types (T) by which the kinds of decision opportunities and decision makers' knowledge are also classified.

Decision makers are specialized in different types of problems to different degrees. Specifically, a decision maker i has a knowledge vector $K_i = \{k_{i,1}, k_{i,2}, \ldots, k_{i,T}\}$, each element of which represents the depth of knowledge or the amount of specialized effort that can be made in each time period to solve problems of the corresponding type. As our interest lies on the implication of how to organize individual learning processes, we control for any difference in individuals' cognitive capability by assuming that a decision maker's knowledge capacity is fixed to be one – i.e., $k_{i,1}+ k_{i,2}+ \ldots + k_{i,T} = 1$ ($0 \leq k_{i,t} \leq 1$).

The environment is characterized by three, collectively exhaustive aspects of knowledge demand: intensity, diversity, and turbulence. Specifically, to keep the model simple without losing generality, we first fix the arrival rate of decision opportunities and problems to be constant. Then the intensity of knowledge demand or problem difficulty is modeled as a given amount of specialized effort (E) required by a problem for its resolution. The diversity of knowledge demand is represented by the number of problem types (T), and its turbulence is formalized in a way that the type of the arising problem and decision opportunity is chosen randomly. Environmental uncertainty is therefore conceptualized as unpredictable (random) changes in the demand of certain kinds of problem-relevant knowledge over time.

Organizational Structure

Among others, we focus on the organizational structure of participation constraint which determines who get to deal with what kinds of problems in the decision-making process. We examine three stylized organizational forms which represent different degrees and ways of participation constraint: *unsegmented*, *hierarchic* and *specialized* structures. Under the unsegmented structure, decision makers can be involved in any decision opportunity, while only the decision opportunities of the same type are accessible under the specialized structure. The hierarchic structure represents in-between cases where some decision makers may participate in a broader range of decision opportunities than others depending on their types. Specifically, access to decision opportunities of type m ($1 \leq m \leq T$) is allowed for decision makers of type $n \geq m$. Under specialized structure, access to a decision arena of type m is allowed for decision makers of type $n = m$.

Decision Making and Problem Resolution

Decision makers in the organization attempt to make choices, which may be easy or difficult depending on associated problems. Problems and decision makers continue to be mixed and matched with respect to available decision opportunities. This process is done from the viewpoint of boundedly rational human beings, and may be therefore myopic and imperfect (Cohen et al. 1972, Levinthal and March 1993, Nickerson and Zenger 2004, Simon 1991). Such boundedness in matching is operationalized with a simple behavioral rule: a decision maker participates in a decision opportunity which, as a result, becomes most likely to be made among the accessible ones. Put differently, a decision maker looks for a decision opportunity with easily solvable problems, which is consistent with the behavioral bias toward exploitation (March 1991). This depicts a process of dynamic coordination in decision making where decision makers and problems are fluid or vary over time (Bendor et al. 2001, Cohen et al. 1972).

With respect to a decision opportunity, the specialized effort of the participating decision makers is accumulated and contributes to resolving the associated problem. Specifically, the specialized effort of a current participant for a decision opportunity of type m (the m-th element of her knowledge vector) is added to the past stock of accumulated effort for the decision opportunity. If this cumulative sum of specialized effort is greater than the sum of the required effort of the associated problems, and if there is at least one decision maker[2], the decision is made and the associated problems are solved. The idea of the stock of specialized effort captures the intuition that current problem-solving is a function of prior efforts as well as the efforts of current participant(s).

Learning and Specialization

A key assumption is that the scope and depth of decision makers' knowledge adapt to the problems they deal with, while the total capacity of knowledge and the learning rate are constant and homogenous across them. This assumption is operationalized as follows. At a given time point t, the knowledge vector $K(t)$ of a decision maker who is working on a decision opportunity of type m adapts to a unit vector U_m with m-th element of 1 and other elements of 0, with a learning rate of p, with $K(t)$ as an exponentially weighted average of prior knowledge: $K(t) = pU_m + (1 - p)K(t\text{-}1)$.

This formulation captures two important aspects of experiential learning. First, a decision maker learns more about a problem when she knows less about it and thus solving it is more challenging. Second, decision makers forget about what they are not concerned with or committed to so that learning about problems of a certain type and unlearning about problems of other types coincide (Dierickx and Cool 1989). This assumption of limited capacity of knowledge becomes more intuitive when it comes to the knowledge of specialized professions such as managers, engineers, or lawyers in specific fields. Such specialist knowledge can be achieved and kept up-to-date through continuous commitment to learning by doing processes.

Analysis and Results

The analysis examines the influence of organizational structure on both experiential learning by the decision makers and their dynamic coordination for problem solving. The analysis based on the model suggests that hierarchical participation constraint promotes adaptive learning and coordination

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[2] In the original garbage model (Cohen et al. 1972), a decision can be made without a decision maker (decision by flight), which Bendor et al. (2001) criticized as "ghost energy" and found it behaviorally implausible. We address their concern by adding this requirement for decision making.

in the decision making process for dealing with unpredictable influx of diverse problems. As the theoretical underpinning of this argument relies on assumptions about knowledge heterogeneity and experiential learning, we deliberately design two simplified experiments without one or both of the two assumptions. This helps in confirming our argument as well as in understanding the underlying mechanisms.

In experiment 1, we tune down the effect of both knowledge heterogeneity and experiential learning, and assume that decision makers have homogenous knowledge and can deal with any problem. In experiment 2, we assume heterogeneous but constant knowledge of decision makers with which they are capable of handling the problems they face under the given organizational structure. For purpose of presentation, we report here the results for ten types (T = 10), but the qualitative patterns are robust against the number of types. Since other model settings are identical except for the heterogeneity assumption, any differences in the results can be considered as the consequence of heterogeneity in problems and knowledge, since both experiments abstract from experiential learning and knowledge accumulation. They simplify the exposition of the results by focusing only on the dynamic coordination of heterogeneous knowledge.

In experiment 3, we finally bring in experiential learning by assuming that the knowledge of decision makers becomes specialized into the kinds of problems they deal with. Therefore, organizational structure, which constrains who can deal with what kinds of decision problems, influences the distribution of individual knowledge and problem-solving efficiency in the future. The two simplified models in the experiment 1 and 2 provide a baseline to examine this dynamic and endogenous process of structure-constrained knowledge accumulation and application.

Experiment 1: Homogeneous Knowledge

The simplified model for this experiment assumes homogeneous and thus constant knowledge of decision makers. Specifically, every decision maker can make an effort of 1 and every problem requires an amount of effort E for resolution which is parameterized as problem difficulty. Since the organization has ten decision makers and encounters a new problem in each period, problem difficulty is calculated as $E/10$.

Figure 1 presents the problem-solving rate of different organizational structures. The result shows that the unsegmented structure outperforms the hierarchic and specialized structures over the whole range of problem difficulty. The intuition is somewhat straightforward. Given amount of available effort of decision makers, problem-solving efficiency can be enhanced by reducing wasted effort. As the kinds of problems and decision opportunities arising from the environment vary over time, structural segmentation or constraint could generate idle decision makers who fail to find an accessible decision arena, which results in the waste of their effort. In contrast, unsegmented structure allows decision makers to join any decision arena, and thus decision makers are less likely to remain idle. By this logic, the amount of wasted energy is expected to increase with the degree of structural segmentation so that specialized structure performs worst. The result in Figure 1 confirms this conjecture.

< Insert Figure 1 about here >

Experiment 2: Heterogeneous Knowledge without Learning

In this experiment, we examine the effect of knowledge heterogeneity at the individual level on problem-solving efficiency at the organization level. The second simplified model assumes that problems of each type require corresponding knowledge to be solved, and decision makers have necessary knowledge to deal with the problems they face under the given structure. Under the unsegmented structure, every decision maker has a knowledge vector of {0.1, 0.1, …, 0.1}. Under the specialized structure, a decision maker of type *m* has a unit knowledge vector with *m*-th element of 1 and others of 0. The scope of knowledge varies across decision makers under the hierarchic structure, depending on their type. A decision maker of type *m* has a knowledge vector with *m*-th to *T*-th element of 1/(*T*-*m*+1) and the other elements of 0. This distribution of knowledge is an operationalization of the assumption of limited knowledge capacity. Thus, those with broader knowledge is less efficient in solving a certain type of problems than those with narrower knowledge specialized in the problems of that type. Other model settings are the same as those of the first experiment so that any differences in the results are caused by heterogeneity in knowledge or specialization. In addition, as none of the model changes affects the initial condition and model dynamics under the specialized structure, its result can be used as a benchmark.

Figure 2 presents the result corresponding to that of Figure 1. Two qualitative patterns are observed. First, the overall problem-solving efficiency of the unsegmented and hierarchic structures has declined below that of the specialized structure. Second, the worst-performing structure is the unsegmented one which performed best in the previous experiment without knowledge heterogeneity. Understanding of the first result is relatively straightforward. Because a problem requiring a certain kind of knowledge cannot be solved by a decision maker whose knowledge scope does not cover that specialized knowledge, the matching between decision makers and problems simply became more difficult and thus induces more waste of available efforts. The non-trivial result is rather the second one.

< Insert Figure 2 about here >

Why does the unsegmented structure perform worse than the hierarchic and specialized structures? The unsegmented structure in the previous experiment had an advantage at coordination because it allowed the decision makers to participate in and contribute to any decision opportunity. The premise was that every decision maker had homogenous knowledge which can be applied to solving any problem. The presence of knowledge heterogeneity, however, undermines this advantage of the unsegmented structure. Although decision makers can access every kind of decision arenas and collaborate to solve associated problems, they're efficient in none of them because their knowledge for a certain type of problems is shallower than those specialized in dealing with such problems. The poor performance of the unsegmented structure implies that the advantage in coordination (the scope of knowledge) is dominated by the disadvantage in specialization (the depth of knowledge). This also explains why the specialized structure performs best. The hierarchic structure falls in between. It has decision makes how can access a broad range of decision opportunities while there is also someone with a narrow but deep knowledge specialized in a certain kind of problems.

This experiment is a stark setting which highlights why specialization is valued in the world of diverse problems. Taken into account together with the value of coordination, we face the classical question: How can an organization take advantages from both specialization and coordination to enhance its capability to deal with dives problems? More specifically, we're particularly interested in how to manage to help members attain and apply necessary knowledge in a coordinative manner? The next experiment suggests that hierarchical participation constraint could be a useful principle when organizational members learn from what they work on.

Experiment 3: Heterogeneous Knowledge with Experiential Learning

This experiment of our focal interest is designed to examine how the organizational structure affects both the knowledge accumulation process (specialization) at the individual level and the knowledge application process (coordination) at the organization level. Compared to the previous experiment, we ask about the origin of members' knowledge and assume that they learn from their work experiences. Thus, the organizational structure not only constraints members' participation but also allocates learning opportunities. An important change is made to the model of the previous experiment: decision makers' knowledge vector adapts to the kinds of problems they deal with in a weighted average manner with a given learning rate p (i.e. the knowledge of a decision maker adapts based on problem-solving experience). As described in the model section, this learning about problems of a certain type comes at the cost of forgetting about problems of other types they do not work on, so that the scope and depth of their knowledge change over time. Again, the change does not alter the model dynamics under the specialized structure, its result can be used as a benchmark to examine how the problem-solving rate of the other two structures is affected by experiential learning.

Figure 3 shows the result of problem-solving rate corresponding to that of Figure 1 and Figure 2. The result is quite surprising in the sense that the hierarchic structure, which never outperformed in the two previous experiments, rose as a dominating structure in dealing with diverse and difficult problems. Furthermore, this efficiency is enhanced when decision makers learn faster (i.e., higher p). In the environment of easy problems, the specialized structure still outperforms.

< Insert Figure 3 about here >

Why does the hierarchic structure outperform when individuals learn from what they work on? The intuition is that it has both the beneficial feature of the unsegmented structure (coordination) discussed in the experiment 1 and the beneficial feature of the specialized structure discussed in the experiment 2 (specialization). It has those with narrow but deep knowledge who are capable of solving corresponding problems fast as well as those with shallow but broad knowledge who are able to contribute to solving various kinds of problems. What individual-level learning adds to the value of hierarchic structure is that it helps adapt to changes in knowledge demand by shaping the distribution of individual knowledge. The detailed account of this adaptive capability of the hierarchic structure is as follows.

When knowledge demand is concentrated on a certain type of problems, those who are allowed to deal with them could get together and collaborate to solve them. While they are working on the problems, they learn and become more capable of dealing with them. Although they might have broader but shallower knowledge than a specialist who is solely dedicated to that kind of problems, their collaboration and experiential learning enable faster resolution. When knowledge demand is spread out over different kinds of problems, decision makers can work in parallel, eventually solve some of them (probably, those being handled by more specialized persons), and move on to help solve the unsolved. In this divide-and-conquer process, learning also helps to accelerate resolution by deepening the required knowledge in handling current problems. In sum, individual-level learning strengthens the advantage of the dynamic coordination between those with shallower but broader knowledge and those with narrower but deeper knowledge, which enhances the utilization of the limited knowledge and learning capacity of members and eventually enables the hierarchic structure to benefit from both specialization and coordination.

Learning also benefits the unsegmented structure and strengthens the advantage of free participation. However, it's not enough to offset the cost of excessive commitment to a few decision opportunities. As decision makers prefer decision opportunities with problems close to resolution (March 1991), they're likely to participate in a few decision arenas and make redundant or wasteful efforts. The result in Figure 3, in comparison with that of Figure 2, implies that the unsegmented structure does benefit from learning but does not overcome this problem of excessive commitment towards easy decision problems.

With diverse but easy problems, strict participation constraint along members' specialization provides highest return. This is because a decision maker with deep specialized knowledge can easily solve the problems within her knowledge scope without others' help, and thus the organization needs not to worry about adapting to changes in knowledge demand. In this case, any segmentation seeking for the value of coordination provides insufficient return to the loss in specialization.

Discussions

Participation Constraints vs. Participation Rights

In this study, we utilize the concept of participation constraint rather than participation right. This is to be consistent with the assumption of bounded rationality in identifying, classifying and allocating individuals with various scope and depth of knowledge (Simon 1955, 1991, Foss 2007, Kogut and Zander 1992, Miller 2008, Epstein et al. 2010). Given such boundedness, participation constraint allows organizational members to improvise on their participation when there are accessible opportunities. In contrast, the principle of participation rights does not allow for any participation which has not been planned *ex ante*. The difference might be little in our simple model, but it would not be small when we come to larger and more complex organizations in the reality such as business firms, industries or economies.

Knowledge-Based Theory of the Firm

The knowledge-based theory of the firm asserts that the firm exists because it provides organizing mechanisms to facilitate knowledge generation, sharing, and integration which cannot be achieved in the market (Ghoshal and Moran 1996, Grant 1996b, Kogut and Zander 1996, Spender 1996, Foss 2007). To the extent that it focuses on knowledge as the most strategically important firm resource, the knowledge-based view might be considered as an outgrowth of the resource-based view. However, it goes beyond the resource-based view of strategy by also addressing some "fundamental concerns of the theory of the firm, notably the nature of coordination within the firm, organizational structure, the role of management and the allocation of decision-making rights, determinants of firm boundaries, and the theory of innovation" (Grant, 1996a, p.110).

An important theoretical challenge that remains largely unaddressed is to understand how the elements of the organizational context such as structures, tools, and routines shape the organizational learning process and vice versa (Argote and Miron-spektor 2011, Levitt and March 1988, Nickerson and Zenger 2004). An organization's tasks interact with its organizational context, provide its members with experiences, and create knowledge. Knowledge acquired by learning is embedded in the organization's context and thereby changes the context as well. This study contributes to the knowledge-based theory of the firm by unpacking the interdependent knowledge processes and demonstrating when and why hierarchical participation constraints – which can be effectively achieved within organizational boundaries – enable efficient and adaptive knowledge accumulation and application. The mechanisms discussed above provide us with insights into how 'organizational knowledge' is created, distributed and applied through the interactions of individuals and tasks, and how managers can influence theses processes by revising the formal aspects of organization.

The fit between hierarchical participation constraint and the behavioral assumptions of bounded rationality, experiential learning, and limited knowledge capacity suggests that the same principle could be applied to upper-level organizations such as industries and economies. The economy consisting of markets and firms might be structured in the same manner of hierarchical participation constraint and knowledge distribution. If knowledge is indeed the important source of competitive advantage, this form would have been favored by selection forces as it promotes and balances specialization for efficient knowledge accumulation and coordination for effective knowledge application.

Implications for Empirical Studies

Our theory suggests some testable empirical hypotheses: the correlation between hierarchical participation constraint, hierarchical distribution of knowledge scope, and organizational or innovation performance. This inquiry assumes that both the degree of specialization and the distribution of heterogeneous knowledge among members matter. The empirical issue here would be to measure the degree of hierarchical participation constraint and knowledge distribution. Decision structures, role descriptions, task specifications, or work histories may be useful. To enhance reliability of measurement, it would be a good way to focus on service industries where firms are usually engaged in human-resource intensive activities based on specialized knowledge. Such focused research is also expected to reveal more significant empirical findings.

Another application of the theory could be made to examine the implication of changes in a firm's boundary for the performance of other firms in its value chain as well as itself. This inquiry relies on the conjecture that a value chain or industry, as an upper-level organization, may also benefit from the principle of hierarchical participation constraint (i.e., hierarchically overlapped firm boundaries). For example, we can compare car-manufacturing companies whose value chains are different in the degree of overlap in production and sales activities of member firms. One value chain might consist of firms operating on the basis of distinct scopes of specialization while another value chain might have firms collaborating in developing or integrating parts. Our theory suggests that such differences in the organization of firm boundaries may lead to differences in dealing with changing demands for different cars or adaptive innovations.

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Figure 1. Problem-Solving Efficiency: Homogenous Knowledge

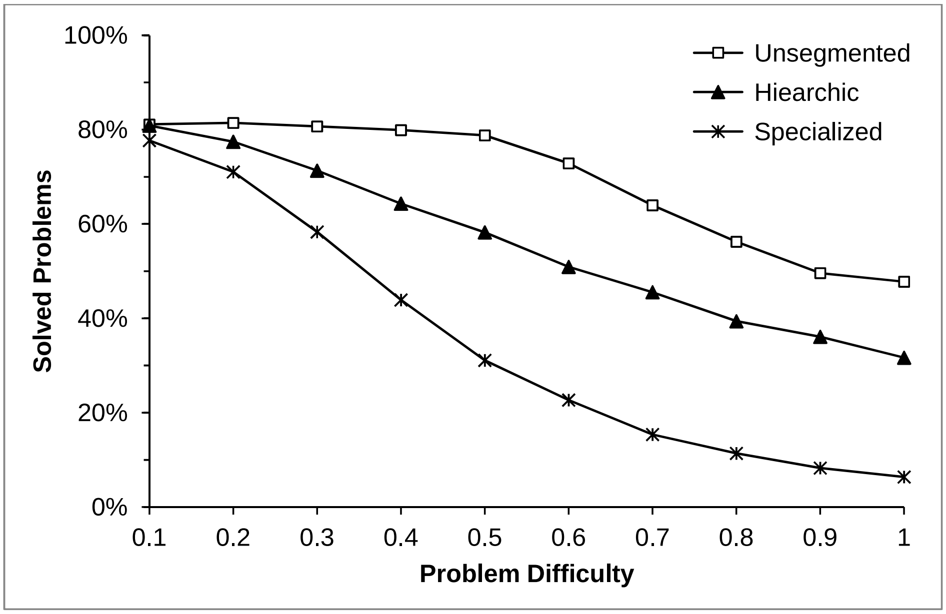


Figure 2. Problem-Solving Efficiency: Heterogeneous Knowledge without Learning

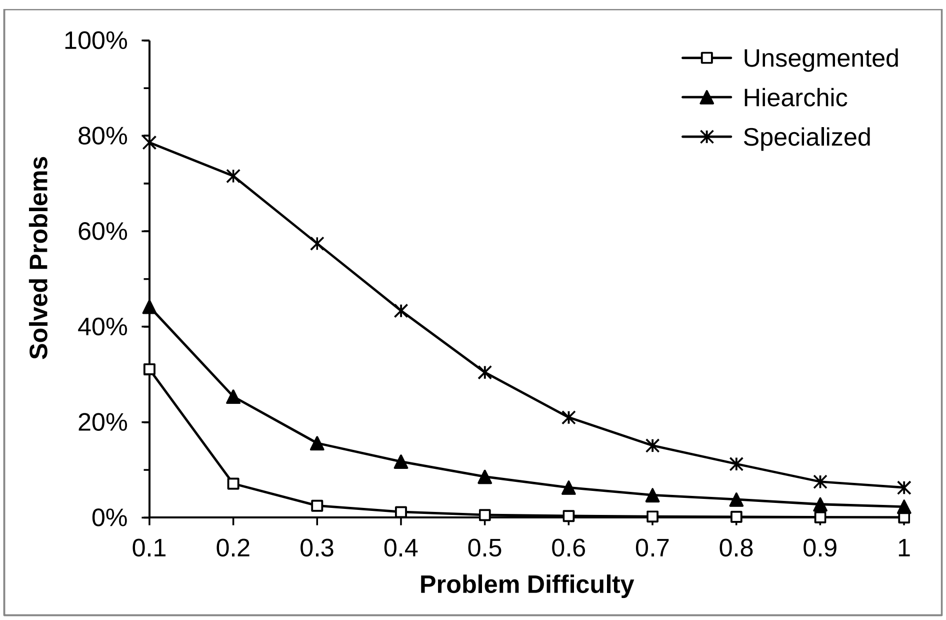
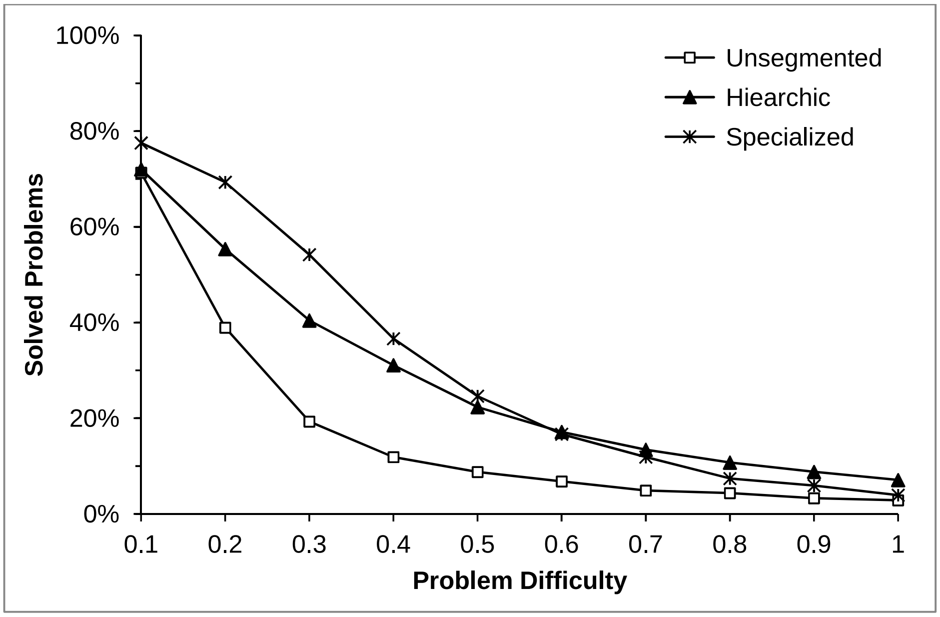


Figure 3. Problem-Solving Efficiency: Heterogeneous Knowledge with Learning

(a) Slow learning (p = 0.2)



(b) Fast learning (p = 0.8)