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Knowledge, Communication, and Organizational Capabilities

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This paper attempts to bridge a gap between organizational economics and strategy research through an analysis of knowledge and communication in organizations. We argue that organizations emerge to achieve the intensive use of the knowledge that is acquired to perform specific tasks and to integrate dispersed knowledge that is embodied in different human minds. The attributes of the tasks undertaken determine the optimal acquisition and distribution of knowledge. Depending on the codifiability of knowledge, different communication modes arise as a coordination mechanism to deepen the division of labor, leverage managerial talent, and exploit the increasing returns to knowledge. Organizational processes can be adapted through codes and culture to facilitate coordination; organizational structure can be designed to complement the limitations of human ability. We stress that organizational process and structure construct the core of organizational capital, which generates rent and sustains organizational growth. From the analysis, we draw implications for the strategic management of knowledge and human resources in organizations.

Key words: task-based approach; complementarities and substitutability; codifiability of knowledge; horizontal and vertical communication; codes and culture; organizational architecture; organizational rent; organizational growth
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1. Introduction

As Hayek (1945) pointed out, organizations exist, to a large extent, to coordinate and integrate disparate information and narrowly specialized knowledge to achieve efficient economic outcomes. This paper presents a unified framework to analyze the optimal acquisition, distribution, and coordination of knowledge in organizations, based on recent economic studies of the cognitive aspects of organizations. We relate the theory to the strategy research on organizational capabilities, knowledge production, and human resource management.

The core of our analysis is a task-based approach. An organization is regarded as a collective group of workers who implement a set of tasks that generate payoffs. The attributes of tasks confronted are a characterization of the production technology, the external environment, and the limitation of human ability. The complexity of a task determines the level of knowledge required to complete the task. The relationship between tasks regulates the distribution of knowledge among separate individual workers. In particular, performing complementary tasks leads to a homogeneous team with an emphasis on knowledge sharing, whereas performing substitutable tasks leads to a heterogeneous team with an emphasis on individual expertise and superstars.

The distinctive property of knowledge lies in the fact that knowledge, once acquired at a fixed cost, can be used many times and by different people without diminishing returns. To exploit these increasing returns to scale is the most basic goal of knowledge-based production. However, the knowledge required to solve economic problems is usually fragmented among different individuals, which limits the intensive use of knowledge. In our task-based approach, the fundamental organization issue is how to efficiently match solutions generated by knowledge with problems encompassed by tasks. Communication naturally arises as the most prominent mechanism to coordinate dispersed knowledge and achieve intensive utilization of knowledge.

We distinguish knowledge on the basis of its codifiability—the extent to which knowledge can be expressed, classified, and transferred. We examine the effects of communicating different types of knowledge on the degree of specialization, the extent of knowledge leverage, and the hierarchy of organization. If knowledge is perfectly codifiable, it is costless for a specialist to find other specialists whose knowledge is complementary to his or her own knowledge. Horizontal communication among as many specialists as possible is the most efficient way to utilize knowledge. Only when knowledge is tacit in nature and costly to codify does vertical communication become necessary to facilitate the matching between problems and solutions. With costly communication, a knowledge hierarchy with specialized problem

solvers at the top and production workers at the bottom, as shown by Garicano (2000), emerges to intensify the utilization of knowledge through leveraging top talent. In this case, the role of management is to acquire and transmit superior knowledge to direct subordinates, and the degree of specialization is limited by communication costs.

We go further to explore the view that organization is "artificial science" that can be designed optimally under the constraint of bounded rationality (Simon 1969) and that the coordination device, such as communication, is in-built in the organization rather than exogenously prescribed to the organization (Arrow 1974). We discuss two important aspects of organizational design: (1) cognitive codes and culture that form a part of organizational infrastructure, and (2) organizational architecture that is developed to mitigate bias and control errors in individual judgment.

Our analysis stems from the pioneering work on information, coordination, and economic system (Hayek 1954, Arrow 1974). We articulate the costs and benefits of coordination and endogenize organizational structure and process as a response to the attributes of tasks confronted and the required knowledge input. This task-based approach, formalized by Garicano and Wu (2010), provides a unified framework for further theoretical study of the coordination aspect of organization and opens an avenue for corresponding empirical research.

This study is closely related to the knowledge-based theory of the firm, in which the firm is conceptualized as a nexus of knowledge (e.g., Kogut and Zander 1992, Conner and Prahalad 1996, Grant 1996). Our research also complements the resource-based theory (Wernerfelt 1984, Barney 1991, Amit and Schoemaker 1993) and the dynamic capabilities theory (Nelson and Winter 1982, Teece 1982, Teece et al. 1997), in which the unique and hard-to-imitate resources provide the basis for firms' competitive advantages. This paper makes three contributions to this broad literature. First, we unpack organizational capabilities into task-specific ability. Second, we highlight the role of communication in information building (knowledge acquisition) as well as information processing (knowledge integration). Third, we stress that organizational process and structure can be regarded as a form of organizational capital, and organizational rent and growth comes not only from the core technological competency but also from the core organizational process.

Because we take the view that tasks are performed by the knowledge that is embodied in the human mind, our theory has implications for strategic human resource management or talent strategy. Our study explains the heterogeneity in managerial practices across economic activities (e.g., exploring versus exploiting activities), across industries (e.g., manufacturing versus creative industries), and across countries (e.g., the American versus the Japanese way). The analysis also sheds new light on some conventional managerial wisdom such as the hiring of star employees, the establishment of organizational culture, and the empowerment of human capital.

The rest of this paper is organized as follows. The next section lays out the conceptual framework and outlines the principal economic rationales. Section 3 sketches a case in which resources are allocated by an invisible hand—a mighty resource manager. In §4, we explicitly introduce the visible hand—communication—to analyze the coordination role of knowledge management. Section 5 extends the analysis in §4 to investigate an important aspect of organization—codes and culture. Section 6 concentrates on how organizational architecture and the resulting communication pattern affect decision making. Section 7 attempts to establish a dialogue between our relatively narrow economic view of organization and a broader literature on organizational capital, rent, and growth. We conclude in §8.

2. Task, Knowledge, and the Limits of Organization

We conceptualize the basic unit of an organization as the one performing a specific task, which can be selecting projects, marketing new products, conducting research and development (R&D) activities, or hiring employees. In this sense, the basis of an organization is a task-performing unit or a team that is endowed with a production function. We focus on the knowledge-based production, which is the core of professional service firms, R&D activities, and innovative industries, etc. However, more general implications can be drawn from the analysis.

In the knowledge-based production, knowledge is the main input. In this paper, we focus on the type of knowledge that satisfies two conditions: (1) knowledge that is used to solve specific problems, e.g., know-how or expertise; and (2) knowledge that is embodied in the human mind and is thus talent. Under these two restrictions, knowledge is not a public and free good. The acquisition of knowledge is costly, because "all learning takes place inside individual human heads" (Simon 1991, p. 125). The matching of knowledge to specific problems is costly as well. Moreover, the utilization of one's talent prevents the same talent from being used at the same time in other problems. It is exactly these limitations of knowledge that put organization in the center of knowledge production.

We will distinguish different types of knowledge in two dimensions, one focusing on its problem-solving property and the other focusing on its codifiability—i.e., how easily knowledge can be communicated. The efficient organization of knowledge in a production process crucially depends on the attributes of knowledge in these two dimensions.

Along the problem-solving dimension, knowledge is demanded to perform tasks, which can vary from as simple as assembling or bookkeeping to as complex as R&D or fashion design. The complexity of a task reflects the limitation of human ability to implement the task. A certain amount of knowledge is required in order for the problem encompassed in the task to be solved. One convenient way to formalize the complexity of task is the stochastic approach employed by Garicano (2000). This approach admits uncertainty as an inevitable part of the knowledge-based production and characterizes the human limitation with a probability distribution. For instance, a highly positively skewed distribution implies a routine task, because the frequency of encountering a tricky problem is low. In contrast, a highly negatively skewed distribution with a thick right tail implies an innovative task, because tricky problems occur frequently. The production is determined by the marginal cost of acquiring an additional amount of knowledge, which should at optimum equal the marginal benefit of resolving uncertainty. The key issue in the efficient organization of knowledge is to allocate the right amount of knowledge to each of a series of interdependent tasks. In this traditional resource allocation approach, the relationship between tasks governs the allocation of knowledge, and there is little room for coordination to play a role.

Along the codifiability dimension, knowledge is transferrable, and communication makes it possible to integrate dispersed knowledge. Thus, workers do not need to acquire all the knowledge necessary to complete a task. Instead, a worker may acquire only the most relevant knowledge and, when confronted with unknown problems, ask someone else. If knowledge is completely codifiable, it is easy to express, classify, and transfer. A code book or directory is sufficient to reach the people who know the right solutions. However, a large class of knowledge is tacit and requires human experimentation and experience to utilize (Polanyi 1966). This type of knowledge is difficult to explicitly express, codify, and transfer to another person. The division of labor is limited by the costs to coordinate disparate knowledge that is not completely codifiable. The key issue in the organization of knowledge is how to design organizational structures to achieve optimal division of labor, efficient acquisition of knowledge, and intensive use of knowledge.

3. Matching Knowledge to Tasks

If a production process involved a sole task and a single worker, coordination would be unnecessary and organization would not matter. In the modern business, however, most productive activities demand conducting interdependent tasks, simultaneously and/or sequentially. An organization emerges to achieve efficient allocation of dispersed knowledge associated with various tasks and talent embodied in different individuals. The relationship between tasks that an organization needs to perform determines the knowledge characteristics of a team.

Complementarities and substitutability are the two most notable relationships between tasks. Complementarities require a balanced allocation of knowledge and homogeneity in talent, whereas substitutability leads to an unbalanced allocation of knowledge and heterogeneity in talent. This contrasting result was noticed in the early team theory literature (Marschak and Radner 1972) and in the more recent economic studies of corporate culture and knowledge sharing (Crémer 1993, Prat 1996) and of trade and specialization patterns between countries (Grossman and Maggi 2000).

3.1. Complementarities and Homogeneity

The importance of complementarities in modern business has been well recognized in the economics literature (Milgrom and Roberts 1990, 1995; Holmstrom 1999; Roberts 2004). The general principle is that factors that are complements to each other should be sorted and bundled together. Kremer (1993) describes a vivid story about this mechanism: the malfunction of the O-rings, one of the thousands of components in the space shuttle *Challenger* (and probably the cheapest), caused its explosion. Following Kremer's analysis of the O-ring production, we demonstrate that strong complementarities of similar tasks will lead to homogeneous workers through the attainment of similar knowledge levels.

Suppose that a job consists of a number of tasks to be performed or problems to be solved. Each task requires a worker with certain knowledge or talent to implement. The tasks are complements in the sense that all the tasks need to be correctly performed in order to complete the entire job and realize its value. On the one hand, a worker's contribution is amplified through the team size; on the other hand, his probability of success is reduced as other team members may fail. The optimal level of knowledge for an individual worker depends not only on the complexity of his task but also on how all the other tasks are performed. Strong complementarities imply positive sorting and homogeneity in investment: the more knowledgeable one's teammates are, the more knowledge one should learn, because the chance that one's effort will be wasted is lower. A formal analysis based on the stochastic production process discussed above is presented in Garicano and Wu (2010). The basic result is summarized as follows.

RESULT 1. Performing complementary tasks leads to a homogeneous team: workers with similar talent are matched, and workers should be trained to resemble one another. There is little scope for individual superstars.

3.2. Substitutability and Heterogeneity

Although complementarities between tasks are common, some firms encounter tasks that are substitutable to one another. A high-tech company often develops similar products before deciding which one will be marketed. A CEO may ask for alternative solutions to the same problem. The profitability of a movie is almost totally determined by a few stars.

If tasks are strongly substitutable, then production will take place whenever any one of these tasks succeeds. The successful implementation of the task by one worker makes other workers' work unnecessary. On the other hand, the marginal value of a worker's knowledge increases in the ignorance of his teammates, because his knowledge must substitute theirs. This tension between workers' knowledge implies negative sorting of talent.

RESULT 2. Performing substitutable tasks leads to a heterogeneous team: the more talented workers should be matched with the less talented ones; a worker should acquire more knowledge when his teammates become less talented. Superstars play a key role in the team.

In reality, many production activities are a hybrid of complementarities and substitutability. Consider the combination of basic and applied knowledge in production. Usually, basic knowledge is complementary to a variety of applied knowledge. However, the specific applied knowledge developed may substitute other applied knowledge. In the hybrid cases, the pattern of organizational knowledge can be fairly complicated, but the general principle in the above analysis remains the same: the allocation of knowledge to task should be governed by the complexity of the main task and the relationship between tasks.

3.3. Managerial Implications: Put Your Talent in the Right Position

The above discussion highlights two typical production processes: the O-ring production represents complementarities and the creative production represents substitutability. The distinct relationships between tasks yield contrasting managerial implications—in particular, for talent strategy.

3.3.1. Are Japanese Managerial Practices Unique? It has been claimed that the Japanese firms often have different managerial practices than their Western counterparts (see Womak et al. 1990). For example, the Japanese firms emphasize multiskilled employees, knowledge sharing, and process improvement. From our point of view, these "distinct" features are actually not specific to Japanese firms. They stem from the complementarities in the lean manufacturing in which the Japanese firms have developed their comparative advantages. A key aspect of lean manufacturing is no tolerance for defects—in Toyota, a worker who detects any defect may stop the whole production line. Thus any task or any component of a task is crucial for success. When failure occurs, the whole system needs to be overhauled. The gain from improving one single task on its own, no matter how significant, is small. Therefore innovations tend to take the form of process improvement, because improvement in one task needs to be complemented by improvements in others. As we have shown, complementarities in tasks lead to homogeneity of talent; the use of on-the-job training, multiskilled employees, and knowledge sharing are tools to harmonize the talent of employees.

The talent distribution in the workplace can reinforce the pattern of specialization at the industrial level and lead to different comparative advantages at the country level. For example, Grossman and Maggi (2000) argue that possibly because of education, on-the-job training, and managerial practices, Japan has a more homogeneous workforce and thus tends to specialize in the production processes with strong complementarities, such as manufacturing high-quality cars. In contrast, the United States has more heterogeneous workforce and specializes in processes with more substitutable tasks, such as software or movies, etc., in which superstars play a big role and winners take all markets.

3.3.2. Explorers and Exploiters. Explorer and exploiter firms (March 1991) have a different structure of tasks. Exploring is characterized by substitutability: when exploring for a new project, a team succeeds as long as any one member comes up with a great idea. Thus in the production process of creative activities, rather than seeking a homogeneous team and spreading the talent around, firms should endeavor to create a star team that absorbs the best talent. This kind of talent strategy is often used in R&D divisions in companies, in which high talent (e.g., well-known scientists) is concentrated on the most promising tasks and junior researchers (e.g., postdocs) work independently on similar tasks to try to increase their chances of success. When a bottleneck is encountered, talent should be diverted to alternative ways to approach the job. It is in the exploration process of this kind where superstars can realize their value. R&D, movie making, fashion design, and many other creative activities share this feature; their success relies on a team in which a few stars dominate and less talented employees are hired as supporting staff.

Exploitation tasks, on the other hand, are characterized by complementarities. Competitive advantage in exploitation is attained by low costs, on-time delivery, and fast responses to customers' needs. Thus exploitation requires that each individual undertake his or her task without defect. As our analysis has shown, this implies that exploitation requires a balanced assignment of talent to tasks. If the allocation of talent is unbalanced, the top talent is wasted. This underlies the

warning of the danger of hiring superstar employees (Groysberg et al. 2004, Huselid et al. 2005). The value of an "A player" can be discounted substantially in a "B position" and in a "B team" when the tasks conducted by each member are complementary to one another.

3.3.3. Sequential Production. As Kremer (1993) noted, when a series of tasks are performed sequentially, it is of great importance to allocate talent in the right sequence. In a complementary production process, the highest talent should be involved in the later stages of production, because getting things right is more valuable at these stages. On the contrary, the most talented workers are hired to try the job at the very beginning if the sequential tasks are substitutable. This explains why an innovative enterprise often starts with a few highly talented entrepreneurs.

3.3.4. Complexity of Tasks. In the O-ring production characterized by Kremer (1993), the match between talent and tasks is governed by the relative complexity of tasks, and more knowledge and talent should be allocated to the more complex tasks. When tasks are substitutable, it is the relative hazard rate of the knowledge distribution of a task (the probability of one's success conditional on others having failed) that determines the allocation of knowledge and talent. When tasks are not very complex in the sense that the probability of encountering tricky problems is not high, talent ought to be allocated to various tasks, and more talent should be assigned to the trickier problem, because the (conditional) marginal probability of completing the task is high. This may be true for mild innovative processes. When innovation is drastic, tasks are usually fairly complex, and the probability of encountering difficult problems is high; allocating too much talent to the harder tasks is not worthwhile.

4. Communication as a Coordination Mechanism

In the previous section, an organization is in essence a team that executes multiple tasks. There is no specific mechanism to integrate knowledge and coordinate talent. While highlighting the role of the attributes of tasks in determining organizational knowledge, this simplification limits rich organizational structures, which may allow for more efficient use of knowledge. Recent research has emphasized the function of information processing and communication in organization (e.g., Geanakoplos and Milgrom 1991, Radner 1993, Bolton and Dewatripont 1994, Van Zandt 1999, Garicano 2000). Based on this literature, we investigate how communication between workers functions as a knowledge-integrating mechanism and how organizational structure and talent allocation are affected by the presence of communication. The key issue is whether knowledge can be divided so that it is easy to know who knows what and who one should ask for help. In this section, we distinguish two types of knowledge on the basis of its codifiability and the corresponding communication modes.

4.1. Completely Codified Knowledge and Horizontal Communication

When knowledge is codified, it is easy to explicitly express and record in the form of hard data, scientific formulae, or coded procedures. The cost of knowing who knows what, and thus matching specialists with solutions, is low. Horizontal communication across specialists who perform different tasks is sufficient to achieve intensive utilization of knowledge. We illustrate this idea with an extreme situation in which knowledge is completely codified so that everyone can instantly match problems with the agent who can solve them.

Consider a team with n members to carry out production that involves problem solving. Without communication, the workers perform the same task independently. In essence, each member works in isolation using only his or her own knowledge. From the perspective of the whole team, the same piece of knowledge is acquired n times in order to use it n times. Knowledge is not used intensively, and some talent is wasted. When knowledge is completely codifiable, the team members can divide their labor to specialize in nonoverlapping subsets of knowledge and integrate them into overall organizational knowledge through communicating compatible codes. Therefore the cost of acquiring each piece of knowledge is paid once, but the knowledge is used n times. This is the fundamental economic rationale of using knowledge pointed out by Rosen (1983): knowledge implies a fixed cost independent of its subsequent utilization, and thus it always pays to let workers learn a narrower set of tasks and use it more intensely. In the words of Arrow (1974), once an information channel is established, there are increasing returns to its uses.

The division of labor allows an organization to acquire more knowledge than when communication is absent. This is precisely because more intensive use of knowledge increases the marginal benefits of acquiring knowledge. Moreover, the organizational knowledge and the degree of specialization increase with each other. This reinforcement effect is due to the implicit complementarities between each member's knowledge: the presence of other members' knowledge increases the value of one's knowledge.

Communication of codified knowledge can be impersonal and takes the form of market transactions of knowledge. If communication is costless, the optimal division of labor is either 0 or N, an exogenous upper bound of the market size. Knowledge, once used, is used as many times as the market allows. This echoes the great insight pointed out by Smith (1965) and elaborated

on by Stigler (1951) and Becker and Murphy (1992): "The division of labor is limited by the extent of the market." For example, in a small rural area, a doctor is usually a generalist, dealing with all kinds of diseases. There is little scope for a specialist because the demand for one particular piece of specialized knowledge is too small and the multiplication of special talent is not large enough. Only in large markets does the division of labor among doctors emerge: internists, dermatologists, pediatricians, etc., are common in cities.

We summarize the basic results as follows.

RESULT 3. When knowledge is completely codified, horizontal communication between specialized workers is the norm, and the extent of talent specialization determines the efficiency of an organization; the role of management is substituted for by effective information coding and transmission; and the degree of specialization is limited by the extent of the market.

In the above analysis, the enormous benefits of specialization arise because knowledge is perfectly codified, and thus it is costless for a specialist to find other specialists whose knowledge is complementary to his or her own knowledge. In consequence, knowledge, although embodied in different human minds, can be used freely after incurring an acquisition cost. When knowledge is not perfectly codifiable, the public good feature of knowledge no longer holds. Horizontal communication should be replaced by vertical communication.

4.2. Noncodifiable Knowledge and Vertical Communication

Knowledge is seldom perfectly codified, and communication is rarely costless. A large class of knowledge is tacit and is hard to formalize, express, classify, and transfer. To solve a problem, workers need to discuss, clarify, and verify the information encompassed in the problem to be solved. Because of this ambiguous nature of tacit knowledge, a precise assignment of talent to problems is impossible, and horizontal communication between specialists with nonoverlapping knowledge would incur high costs to search for the right people to solve unknown problems. As shown by Garicano (2000), this difficulty of matching problems with solutions when knowledge cannot be codified leads to another pattern of specialization: the "knowledge hierarchy."

Suppose that knowledge is completely noncodifiable. This is the case when knowledge can only be acquired through experience and on-the-job training. Specialists with nonoverlapping knowledge cannot understand each other, and horizontal communication is impossible. Asking for help has to take the form of vertical communication: only people who have acquired the same knowledge can identify what the problem is and use their superior knowledge to solve the problem.

Consider a team of n members to carry out production. There are two organizational alternatives: a one-layer structure in which all members devote their time to production and a two-layer structure with $n-1$ production workers and one manager who can help the workers to solve problems. Compared with the one-layer structure, the advantage of the two-layer organization comes from two sources. First, the manager can specialize in helping workers to economize costly communication between workers. Second, the division of labor between the manager and the workers allows the former to acquire more knowledge or focus on more unusual problems. The hierarchy trades off between the leverage of the manager's knowledge and the replacement of horizontal communication with vertical communication. The optimal size of the team also depends on the knowledge distribution between the manager and the workers. The manager's span of control increases in the workers' knowledge because a more knowledgeable worker asks fewer questions and gives more time to other workers.

In a general framework, Garicano (2000) shows that a pyramidal knowledge hierarchy, with several successive layers of problem solvers of a decreasing size, emerges to achieve a more efficient use of knowledge. In such a structure, the knowledge of the solutions to the most common and easiest problems is located at the production floor, whereas the knowledge about the more exceptional and harder problems is located at the higher layers of the hierarchy. Problems, when unsolved, are passed on until the probability of finding the solution is too low to justify continuing the search. By adding layers of problem solvers, an organization saves the cost of knowledge acquisition at a lower level and increases the utilization rate of the knowledge at a higher level. We summarize the basic insight as follows.

RESULT 4. When knowledge is noncodifiable, the mode of communication is vertical, and a hierarchical structure emerges to leverage top talent; the role of management is to acquire and transmit superior knowledge to direct subordinates; and the degree of specialization is limited by the communication cost.

What determines the mode of communication, horizontal or vertical, is essentially the coordination cost to match problems with knowledge. When knowledge is perfectly codified, this technological easiness mutes the role of a separate and superior individual who takes the responsibility of coordination. Then horizontal communication supersedes vertical communication, because the former allows for the saving of overlapping knowledge. If knowledge is not perfectly codifiable, acquiring overlapping knowledge may smooth coordination, and vertical communication dominates.

4.3. Managerial Implications: The Role of Managers

We have analyzed the role of communication as an organizational process to integrate dispersed knowledge.

The general function of communication is to allow for specialization of knowledge and division of labor. For different types of knowledge, different modes of communication are adopted, and different talent strategies are deployed.

4.3.1. Knowledge Hierarchies and Management by Exception. Knowledge hierarchies permit high talent to specialize in exceptional problems. This "management by exception" was well stated by Sloan (1924, p. 195), who in describing his job, claimed that "we do not do much routine work with details. They never get up to us. I work fairly hard, but it is on exceptions . . . not on routine or petty details." In the presence of costly communication, hierarchies arise, with the more knowledgeable workers placed on the top as managers. These managers acquire knowledge about exceptional problems and specialize in solving problems submitted by their subordinates. A knowledge hierarchy is advantageous only if the size of organization is large enough, which is sustained by better subordinates so that the top managers can be protected from the "dumb" questions that anyone else could deal with.

4.3.2. Expansion of Firms and the Type of Knowledge. We have shown that when the knowledge is tacit, the manager's knowledge is endogenously complementary to the workers' knowledge. This generates an optimal knowledge differential between supervisors and subordinates. Thus, when tacit knowledge is important in the production and communication process, an expansion of firm size by hiring superstar top managers may lead to an organizational failure as mediocre subordinates may compete away too much time of the superstars. A rapid expansion of firm size is more likely to succeed when knowledge is codifiable, because hiring less knowledgeable workers is less likely to tax top managers (because codifiable knowledge of different workers is easy to substitute). Thus a higher level of overall knowledge can be obtained by increasing the team size without increasing each worker's knowledge level.

4.3.3. The Value of Specialists. We have shown that horizontal communication of codifiable knowledge makes the specialization of talent possible. The degree of specialization is limited by the extent of market when communication costs are negligible. However, if information jams occur—for instance, because of incompatible coded knowledge—the degree of specialization is limited by the capabilities of coordination. This yields a nonmonotone relationship between the value of specialization and the scale of economies (either in the market or within the firm). In a new market where customers have not yet come up with specific problems, the value of specialists is very limited. Talent strategy of a firm should focus on generalists. When the market becomes mature, the value of being a specialist increases because their specific knowledge can be used more frequently. The focus of talent strategy shifts to specialists. However, the role of generalists is still important unless information can be perfectly coded and transacted in the market. The degree of specialization is constrained by the ability of the generalists who are able to transmit and coordinate knowledge among specialists.

4.3.4. Differing Impacts of the Advances in Information Acquisition Technology and Communication Technology. The analysis in this section yields rich implications about the interplay between the improvements in information and communication technologies (ICT) and the organization of knowledge/talent. We distinguish between two types of progress in ICT: (1) the knowledge acquisition technology, for example, enterprise resource planning (ERP); and (2) the communication technology, for example, IP-based and wireless communication. When knowledge is codifiable, a decrease in the cost of both communicating and acquiring knowledge increases the level of organizational knowledge and the degree of specialization. However, in the presence of hierarchical structures, the advances in the two types of ICT have opposite impacts on the discretion of the workers at the bottom positions and the managers at the upper positions. Cheaper acquisition of knowledge increases the knowledge scope of workers and thus reduces the frequency of interventions from above. On the other hand, better communication of knowledge reduces the knowledge scope of the workers and increases the need for interventions. Bloom et al. (2011) use detailed international plant-level data and ICT information to show evidence consistent with this theory.

4.3.5. Strategy and Structure in Professional Service Firms. The value of the professional service firms (PSFs) centers on problem solving. In essence, the organization of PSFs is a way to allow the experts (the partners) to leverage their knowledge and exploit economies of scale. Most of the knowledge in professional service is tacit and comes from repeated observation of what works and what does not in practical instances. As a result, the organization takes the form of a knowledge-based hierarchy described above.

We can characterize the market positions of the PSFs by how complicated the problems they face are. Consider the consulting industry. At the lower end are the basic simplest consulting firms, whose jobs are undertaken by stand-alone consultants. Knowledge is cheap, and leverage is unnecessary. Next up are business process consultants (e.g., Deloitte, Accenture), who specialize in more complicated problems that require repetitive and easy-to-leverage knowledge. Thus the knowledge hierarchies have large spans. The highest market position is the "strategy consulting" niche (e.g., Bain, BCG, McKinsey), where the solutions to problems are one-off

and knowledge is hard to reuse. Their organizations need more-skilled consultants, although the leverage ratio is rather limited.

5. Codes and Culture

We have discussed two examples in which knowledge is either completely codifiable or noncodifiable. In reality, knowledge possesses both dimensions of properties: knowledge is partially codifiable. In this situation, organizational codes are an important part of the communication infrastructure of firms and organizations (Arrow 1974) and a shared technical language between workers (Crémer 1993). As economists understand, technological terminologies, company jargons, accounting systems, databases in human resource management, and project management dictionaries are all codes. The major function of these codes is to reduce the coordination time required to identify problems and match them with the right solutions. Communication of partially codifiable knowledge is limited by two forms of bounded rationality. First, workers have a limited ability to learn codes that allow for the identification of exact problems. Second, workers have a limited ability to solve problems that involve incomplete information. Based on this bounded rationality view of organization, Crémer et al. (2007) develop a theory of language and organization. We sketch their basic analysis of optimal codes and organization structures, and we then extend the analysis to organizational culture and draw some managerial implications.

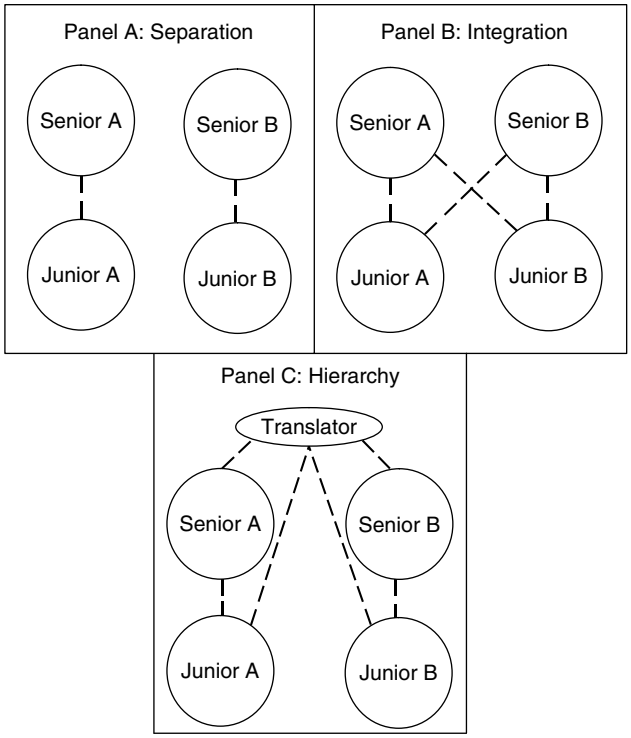
5.1. Optimal Codes and Organization Structure

Miscoded knowledge may lead to ambiguity, confusion, misunderstanding, and inefficiency in communication and production. An optimal design of codes needs to trade off between specialization and commonality. On the one hand, a narrow specialized code facilitates communication within a particular function that performs a task, but it limits communication between functions that perform various tasks and thus makes coordination between tasks more costly. On the other hand, a broad common code improves coordination across tasks at the expense of less precise and more costly communication within a task.

Consider an example in professional service. A consulting firm employs a team of two workers, a senior associate and a junior associate, to serve clients. As in the case of tacit knowledge and vertical communication, the junior associate can ask for help from the senior if he cannot solve a client's problem. The junior can classify problems raised by clients, but not perfectly. The team has to rely on a previously specified and agreed code to coarsely transmit information. Communication costs, which can be regarded as "diagnosis cost" of the problem, depend on the precision of the information sent by the junior associate. Less precise information brings about more costly vertical communication. Therefore a code should use precise words for frequent events and vaguer words for more unusual ones. A trickier task (a more unequal distribution of events) increases the value of a specialized code, because the precision of the words can be more tightly linked to the characteristics of the environment.

Now suppose another team consisting of a one senior and one junior associate is created so as to expand business. Horizontal communication between the two teams (A and B) becomes important because the junior associate in team A (Junior A for short) can ask the senior associate in team B (Senior B) for help in case that Senior A is overloaded. To facilitate horizontal communication, the consulting firm may tailor the original codes for common uses by the two teams. Two possible organizational forms are shown in Figure 1: (1) Separation (the two teams use different codes; panel A) and (2) Integration (the two teams share the same code; panel B). An integrated structure replaces narrower codes with broader ones. Thus the cost of vertical communication within each team increases, but the cost of horizontal communication between teams decreases. The trade-off depends on the synergies and the similarities between the two services and the frequency of their interactions. Separate codes are preferable when synergies are relatively low, when the service demanded by

Figure 1 Communication in Three Possible Organizational Forms



Note. This figure is adapted from Figure 1 in Crémer et al. (2007).

clients is rather different, or when the diagnosis cost is high so that there is a high premium on communicating precisely.

An alternative to the integrated structure that exploits the synergy between two distinct teams is to introduce a hierarchical superior (e.g., a partner) as a translator who enables services with different codes to cooperate. For instance, if Junior A has two customers, he communicates to the translator the type of the "extra" customer in the code used in service A. The translator will then transmit the information to Senior B in the code used in service B (panel C in Figure 1). In this case, an additional information channel is set up, which may incur a fixed cost. But given that the translator has acquired more knowledge and specialized in language, her diagnosis cost is lower than that of the senior associates. The optimal organization choice depends crucially on communication costs and the translator's advantage. Hierarchies are more efficient when communication costs are high, whereas low communications costs favor their replacement by common codes and horizontal communications.

RESULT 5. When knowledge is codifiable, optimal organizational codes balance vertical communication within units and horizontal communication across units; the role of management is to facilitate communication between areas of knowledge by translating different codes.

In Figure 2, we summarize the optimal choice of organizational structure, communication mode, and talent strategy for different degrees of synergies and different levels of information (communication) costs.

5.2. Organizational Culture

Economists have employed the notion of information (knowledge and belief) to understand organizational culture. Kreps (1990, p. 93) defines culture as "the general principle and the means by which it is communicated" and formalizes it as social norms formed through repeated games and implicit relational contracts. Crémer (1993, p. 351) regards culture as "the part of the stock of knowledge that is shared by a substantial portion of the employees of the firm, but not by the general population from which they are drawn." He decomposes organizational culture into three elements: (1) a common language of coding, (2) a shared knowledge of certain facts, and (3) rules of action. Crémer's treatment of culture shares certain conceptual similarity to the treatment by social psychologist. For example, Schein (1992, p. 12) defines organizational culture as a pattern of shared basic assumptions that have developed as a consequence of the organization's attempts to solve problems of "external adaptation and internal integration."

Figure 2 Communication Codes and Organization of Knowledge

Synergies \ Information costs	Low	High
Low	Integrated organization; hierarchical communication; emphasis on translators	Separate organization (with specialized codes); vertical communication; emphasis on specialists
High	Integrated organization (with common codes); horizontal communication; emphasis on generalists	?

The analysis of optimal codes in §5.1 is an example of the cognitive aspect of organizational culture. Codes are a designed "common language" or an explicit form of "shared assumptions." The economic rationale of coding can be extended to the implicit and intangible aspect of culture. A key function of culture is to reduce communication costs or, more broadly, coordination costs. A uniform culture is unusual in a large organization (e.g., IBM), because such a culture would be too broad and vague to promote communication efficiently within each division. It is equally unusual that each unit of an organization forms its distinct culture without sharing some common factors with other units. A successful organizational culture needs to balance between horizontal communication and vertical communication. An overemphasis of sharing common values and beliefs may turn out to be a hurdle when prompt responses to uncertainty are necessary in some units and synergies between units are not sufficiently large.

Culture, as a nexus of explicit and implicit information and knowledge, requires setting up a number of information channels. Thus to build up an organizational culture incurs a significant amount of specific investment and creates, to some extent, irreversible commitments. It is costly to adapt, tailor, and destruct existing codes. A strong culture may cause organizational inertia that resists changes and innovations even if there are no conflicts in the redistribution of benefit. This important aspect of codes and culture remains to be studied in the organizational economics.

5.3. Managerial Implications: Manage Corporate Culture

5.3.1. Manager as Code Translator. When knowledge is codifiable, managers still have the "management by exception" role within a particular area. However, management also serves to facilitate communication between areas of knowledge by translating different codes. Managers not only leverage their own knowledge but are also "traffic cops" able to help workers communicate across areas. It has been recognized that "organizational cultures are created in part by leaders, and one

of the most decisive functions of leadership is the creation, the management, and sometimes even the destruction of culture" (Schein 1992, p. 5). The essence of the T-shape management (Hansen and von Oetinger 2001) is to select a new type of manager, who has the ability to adapt codes quickly. On the one hand, they use broad codes to facilitate knowledge sharing across the organization (the horizontal part of the "T"). On the other hand, they are experts in their own area and thus are able to efficiently utilize the more precise and narrow codes within their division (the vertical part of the "T").

5.3.2. Culture Substitutes Hierarchies. Compared with American firms, Japanese firms adopt more horizontal organizational structure (the publicized "kanban-system" at Toyota) and emphasize more on a common culture (Nonaka and Taceuchi 1995). The correlation between these two aspects can be partially rationalized by the economic analysis of codes and culture. Strong complementarities between tasks or inputs in the production process in the Japanese firms (discussed in §3.3) imply large synergies between different working units. A common culture smooths communication across units and exploits synergies. Culture sharing, reinforced by multiskilled workers, reduces the need for the sophisticated hierarchical translators because workers are all familiar with the same language. With sufficiently close corporate culture, the Japanese firms can even exchange information and coordinate activities across firms.

Corporate culture is sometimes crucial for the achievement of synergies. A notable episode of merger conflicts is the merger between AOL and Time Warner. In his bestseller, Klein (2004) attributed the sad marriage between the two media giants in part to a clash of culture. The lack of common codes for the old and the new media and the conflicts in social norms between the two industrial leaders prevented the new AOL/Time Warner from realizing their synergies, which was the raison d'être for the merger. Moreover, the senior managers in the two companies failed to translate the two "languages" so as to smooth conflicts. Even after the board was well aware of the problems (the two architects of the merger, Steve Case and Jerry Levin, were forced out), the conflicts persisted because the costs to destructively create new codes and norms were enormous.

5.3.3. The Paradox of Centralizing Information Processing and Decentralizing Decision Making at the Same Time. In recent years, the management of information systems, including customer information, accounting systems, and human resource database, in many firms has become more centralized, whereas decision making has become more decentralized. Robert J. Herbold, chief operating officer for Microsoft from 1994 to 2001, describes this apparent paradox: "Standardizing specific practices and centralizing certain systems also provided, perhaps surprisingly, benefits usually associated with decentralization" (Herbold 2002, p. 79). This paradox exactly reflects the role of organizational codes in the design of organizational structure: better management of communication substitutes for bureaucracies and allows for decentralizations. Argyres (1999) provides a detailed case study of the B-2 "Stealth" Bomber, in which a common-access database to manage part designs and an advanced system to perform structural analysis successfully establish a "technical grammar" for communication and thus limit the reliance on a hierarchical authority to force decisions to travel up.

6. Knowledge, Decisions, and Organizational Structure

In the previous section, an organizational structure is an endogenous outcome of interactions between people. An organization can also be deliberately designed ex ante to complement limitations to human knowledge and judgment, the extent to which depends on the attributes of tasks. Following the spirit of March and Simon (1958) and Cyert and March (1963), we consider the context of decision making in organizations. Two issues are of particular interest: How should decision makers be organized to minimize aggregate errors or bias in decision making? How should knowledge be collocated with decision rights? Our discussion focuses on two basic organizational structures: a centralized hierarchical structure and a decentralized structure with delegation of authority.

6.1. Decision Fallibility and Organizational Architecture

This subsection draws on Sah and Stiglitz (1986), who develop a model to illustrate how a hierarchy and a polyarchy differ systematically in errors in decision making, given the extent of individual human fallibility.

Suppose agents in an organization need to evaluate and decide whether to accept a number of projects. However, the agents do not have perfect knowledge: they do not know the exact outcomes of the projects when evaluating them. They may potentially form two types of bias: reject a good project (Type I error in terms of statistics inference) or accept a bad project (Type II error). The agents try to reduce potential errors by a screening function, s, which assigns a nonnegative probability to an "acceptable" project based on individual judgment. With perfect screening, all projects with positive outcomes are accepted, whereas those that yield negative outcomes are rejected. The system of screening does not matter.

However, screening always has defects as "to err is human," and information is never perfect. Consider two alternative organizational structures with two layers. A decentralized organization delegates the agent at the bottom with the decision rights to select projects. A centralized organization requires the agent to pass his

selected projects to a centralized authority for a second selection and final approval. Suppose the screening technology at each layer is identical and accepts the project with the same probability s. Under decentralization, a project is accepted if it is approved by the agent, and the probability that a project gets approved is simply s. Under centralization, a project is accepted only if it passes all evaluators' screening, and the probability that a project gets approved is s^2. Compared with decentralization, centralization reduces the probability of both correct and incorrect decisions. In other words, the incidence of making Type II errors is relatively high under decentralization, whereas the incidence of making type I errors is relatively high under centralization. Following this logic, the optimal choice of organizational structure crucially depends on the comparison of the two types of errors.

RESULT 6. A decentralized organization outperforms a centralized hierarchy if an agent is less likely to accept bad projects than to reject good projects (Type II errors dominate Type I errors) and/or if the benefits resulting from good projects dominate the outcomes caused by the implementation of bad projects.

The above analysis can be extended to more complex screening technology and organizational structures (Sah and Stiglitz 1988, Christensen and Knudsen 2010). The main intuition remains the same. In a decentralized system, an agent makes decisions without intervention from others. The lack of control means "everything goes": projects are more likely to be accepted. However, this is not necessarily bad, even though there is a risk that too many worthless projects will be undertaken. If a project or an activity has a lot of upsides at the very knowledge-intensive stages, a decentralized structure (or polyarchy) tends to outperform a hierarchy. In a more centralized architecture, where projects have to pass through multiple steps in order to be approved, few projects will be accepted. It is likely that whatever passes multiple screening will be good, but some valuable projects will get turned down by the bureaucracy. Again, hierarchies do not mean "bad," although bureaucracy does kill ideas. It is simply the result of a trade-off between killing too many good ideas and letting pass too many bad ones.

6.2. Knowledge and Distribution of Decision Rights

In the previous subsection, there is little scope for knowledge integration. When knowledge is communicated, the distribution of decision rights depends on the properties of knowledge, the channels of information, and the costs of communication and coordination.

Jensen and Meckling (1995) pointed out that there are two general ways to collocate knowledge and decision rights: one is by moving the knowledge to those with the decision rights; the other is by moving the decision rights to those with the knowledge. The former corresponds to centralization and the latter, decentralization. Centralization requires setting up information channels to transfer knowledge from local units. If the knowledge is specific to each local unit, e.g., decisions that are sensitive to local conditions or need to be made quickly, it would be very costly to move the knowledge up to the decision maker who may not have the expertise to decode specific knowledge. Therefore it is worthwhile to decentralize decision rights to the local experts. On the contrary, when the knowledge is general, e.g., similar across units and easy to achieve common understanding, the costs of decoding, assembling, and integrating the disperse knowledge are relatively low. It is more profitable to move general knowledge up to a centralized decision maker to achieve coordination of decisions across units and avoid the loss of control.

Dessein and Santos (2006) develop a theory to incorporate task specialization (division of labor), communication, and coordination in the analysis of organizational design. Their basic idea is that knowledge is local in nature and organizational actions need to adapt to a changing environment. Decentralizing decisions provides local managers with the flexibility to tailor their actions and facilitates the usage of local knowledge. However, in the presence of interdependence between local units, decentralization may hinder the achievement of synergies. Ex post coordination relying on costly communication is called for. Alternatively, organizations can centralize decision making and prescribe a course of action to local managers. This ex ante coordination economizes on communication costs, but local knowledge is ignored. Therefore the central trade-off in organizational design is between adapting to changes and coordinating complementary activities. Job design in terms of task specialization can be used to achieve a better organizational response to the dual challenge of coordination and adaptation. For instance, broader jobs and less specialization tend to facilitate coordination. The main intuitions, along the line of our analysis in the previous section, are summarized as follows.

RESULT 7. Utilization of specific knowledge, delegation of decision rights, and intensive communication are complementary to each other. When the business environment is more uncertain, a decentralized and adaptive organization is more valuable in utilizing local knowledge, and limiting specialization helps to maintain the balance between adaptation and coordination.

6.3. Managerial Implications: Collocate Talent with the Right Power

We have shown that organizational design can be used to handle different types of decision fallibility, knowledge with different transferability, and activities with different predictability. The optimal utilization of knowledge requires collocating talent with the right power.

6.3.1. Why Do Established Companies Fail to Innovate? The trade-off between centralized hierarchies and decentralized polyarchies in limiting decision errors partially explains the surprising fact that well-established firms are not prolific at innovating, although they usually have a much larger reservoir of knowledge and talent than start-ups. In an established firm, reputation increasingly becomes important to sustain the coherence between a corporate image and products. Making mistakes could have a serious negative impact on the firm. Therefore a hierarchical structure is needed to maintain and enhance the reputation. For example, approving new products in a mature firm with a strong reputation will involve a highly bureaucratic process with numerous steps and procedures. Other examples may be an industry subject to intensive public scrutiny or activities such as risk management, where loss is potentially large but gain is little. In centralized organizations with multiple screens, a large amount of knowledge or very talented agents in each layer are not necessary as early mistakes can be corrected. This suggests bureaucracies may optimally suppress talent. Conversely, talent is more valuable in a decentralized organization, where no other agent is located to check whether mistakes are made.

6.3.2. The Urgent Project System. To facilitate innovation, some established firms break through their traditional hierarchical structure and create an independent and highly decentralized organizational structure for new product development. One notable example is the Urgent Project System in Sharp's R&D operations (Nonaka and Takeuchi 1995). This system recruited the best people from various departments within the company and gave its members "the freedom to do whatever is necessary for development" during the project period. The projects proposed by this system need not pass through complicated bureaucratic evaluation and approval. Their proposals were either adopted or rejected, or they were "justified" directly at the highest decision-making meeting at Sharp.

6.3.3. Global Localization. A key challenge to the strategy of the multinational firms is how to achieve a balance between globalization and localization. Bartlett and Ghoshal (1998) identify three eras in the development of the multinational firms: the era of European decentralized federations in the early 20th century, the era of American coordinated federations in the post-World War II era, and the era of the Japanese centralized hubs in the 1970s and 1980s. This evolution of organizational structures of the multinational firms reflects the improvement in coordination (communication and transportation) and the decline of uncertainty in the local markets of the developed countries. Recent globalization, however, has witnessed an increasing emphasis of corporate strategy on local adaptation and empowerment of talent. This shift in strategy is in part triggered by the emerging markets, particularly in the East. For a Western multinational firm, expanding business in the East implies huge opportunities as well as high risks and potentially large conflicts. All of these substantially increase the importance of local specific knowledge and communication costs. A decentralized organization structure has the advantages to prompt decision making and explore profitability. At the same time, multinational firms also employ global product groups and develop managers with broad perspectives to maintain coordination.

7. Organizational Capital, Rent, and Growth

A large body of empirical evidence has demonstrated that the extent of "organizing right" is one of the determining factors explaining the large heterogeneity in firm performance in the same industry (e.g., Brynjolfsson and Hitt 1996, Ichniowski et al. 1997, Black and Lynch 2001, Bloom and Van Reenen 2007, among a rapid expansion of systematic empirical studies and detailed case studies). Industrial leaders are usually not only technological leaders but also organizational leaders. Organizational practices, or, more broadly, managerial practices, are important capital that generates rent and sustains organizational growth.

7.1. Organizational Capital

There exist various views of organizational capital. Prescott and Visscher (1980, p. 447) define organizational capital as information: "What the firm knows about the abilities of its personnel . . . the potential for improving matches between employees and jobs." They also include human capital into organizational capital, regarding organizational capital as embodied in employees as in Becker (1964). Evenson and Westphal (1995, p. 2237) consider "organization capital . . . [as] the knowledge used to combine human skills and physical capital into systems for producing and delivering want-satisfying products." Amit and Scoemaker (1993, p. 36) think of organization capital as strategic assets that are "the set of difficult to trade and imitate, scarce, appropriable and specialized resources and capabilities that bestow the firm's competitive advantage." [1]

Our analysis recognizes the organizational process that optimizes the relationships between tasks, between talents, and between tasks and talents as the core of organizational capital. It is true that information of personnel and knowledge of organizational process are important for the formation of organizational capital. However, information and knowledge per se may not be specific to a firm. It is the process of acquiring, storing, transferring, and integrating information and knowledge that is specific to a firm and whose value is not attributed to other production factors such as physical capital, human

capital, or information. We have shown that communication is a crucial mechanism that integrates knowledge and coordinates talent. Thus communication rather than the communication technology is the organizational capital. For example, a new information system (e.g., ERP) that is introduced in a firm is not organizational capital. It is the process of deploying this information system that forms organizational capital. Organizational processes always involve personal interactions. Therefore organizational capital is accumulated through formally designed process as well as repeated tacit interactions among workers.

We distinguish organizational capital from human capital for theoretical and practical interests although they are always intertwined. The relative mobility of human capital in the market allows managers to identify organizational failure. A sudden collapse of a firm as a result of brain drain is a signal for weak organizational capital. In other words, a firm with strong organizational capital should be able to replace human capital from the market to moderate negative shocks and avoid failure.

Two factors make it hard to measure organizational capital. First, organizational capital is intangible assets and is difficult to measure directly. Second, organizational capital is specific to a firm, and its value cannot be explicitly priced in the market. As a result, one has to rely on some indirect measures or variations to identify organizational capital and its value.

The most common way of measuring organizational capital is to treat organizational capital as "Solow residual" at the firm or plant level (Corrado et al. 2005)—that is, to net out the contribution of other inputs such as physical capital and human capital in a specified production function. However, the "residual" can be contaminated by the technology and knowledge factors that are not contained in the measures of physical and human capital. Moreover, it is not easy to tease out the effects of market demand and supply. Our approach, which stresses the role of tasks, provides new scopes to identify organizational capital, because organization process varies substantially across tasks, which are defined by industrial characteristics, production stage, and product cycle. Furthermore, technologies in particular information and communication technologies have significant impact on organization processes. Variations induced by technological change may allow for identification of the value of organizational capital.

7.2. Organizational Rent

Organizational rent is the economic return to organizational capital. The distribution of firm profits between organizational rent and returns to other factors—in particular, human capital—is an important theme in the organizational economics that is yet to be explored.

One key factor that generates and maintains organizational rent is complementarities. The discussion in §3 shows that complementarities amplify individual talent through two channels. First, complementarities mitigate the extent of decreasing returns to scale at the individual level. Second, the positive sorting induced by complementarities matches high talent with high talent and facilitates the multiplication of individual talent. The amplification effect provides a mechanism through which small differences in individual skill create large differences in performance at the firm level.[2] To the extent that competition is intensified by the availability of sufficiently close alternatives and the homogeneity of workers in the market, each individual cannot capture the overall surplus by leaving the firm.

More generally, the distribution of surplus among production factors is determined by the bargaining between the organization and the workers. In contrast, when talent is substitutable to each other, the surplus is mostly created by the superstars, who can easily appropriate the rent. Our analysis also identifies communication as a source of organizational rent becuase communication works as a knowledge-integrating mechanism that creates complementarities among workers and enhances the value of talent.

7.3. Organizational Growth

The idea that organization can grow through accumulating organizational capital stems from the seminal work by Penrose (1959), who pointed out the significant role of managerial service in the growth of the firm. The theory has been elaborated by the evolutionary view of the firm (Nelson and Winter 1982) and the dynamic capabilities theory (see Augier and Teece 2006 for a review). Our approach articulates several points that complement the existing theory.

As emphasized by the resource/knowledge-based view of the firm, organizational knowledge, which is embodied in the human capital in the organization, is a driver of organizational growth. Organizational process lies in the core of organizational capital and acts as an augmented factor to organizational knowledge through efficient utilization of existing talent and optimal acquisition of knowledge. In particular, organization capital enhances complementarities of production factors inside the firm. Organizational growth often starts with a technology shock that releases existing firm resources such as knowledge and talent. The "excess" resources, maybe in a minor scale, can trigger resource accumulation through a complementary chain and become a significant source of capabilities. For example, an improvement in communication of tacit knowledge allows managers to better leverage their knowledge and increase the returns to their talent, which incentivizes the managers to acquire more knowledge and enforces further leverage of their knowledge. As a result, the organization gradually expands to reach a new equilibrium. Thorough analyses of how exploring complementarities enhances firm performance

are pursued by Milgrom and Roberts in a series of influential research (Milgrom and Roberts 1990, 1992, 1995; Roberts 2004). The danger of the ingrained complementarities is that of falling into the traps of bad equilibrium. Organizational processes may facilitate the decumulation of organizational knowledge and the pace toward bad equilibrium.

Organizational capital itself is accumulable. This is one of the fundamental ideas in the evolutionary theory of the firm. Nelson and Winter (1982, p. 99) claim that "organizations remember by doing" and propose that "the routinization of activity in an organization constitutes the most important form of storage of the organization's specific operational knowledge." In the context of our analysis, communication as an integrating mechanism stores the memory of organizational process. The memory can be expanded through repeated interactions and routinization of managerial practices.

8. Concluding Remarks

We have developed a task-based approach to analyze the optimal acquisition, distribution, and integration of knowledge in an organization, from which we have drawn rich managerial implications. Figure 3 summarizes the logic of our analysis.

The general lesson is that organization emerges to integrate dispersed knowledge and coordinate talent in production and is designed to complement the limitations of human ability; organization is sustained by acquiring relevant knowledge and allocating talent to right positions. More specifically, we stress the following points.

1. Organizational knowledge is task oriented. The complexity of task determines the optimal level of knowledge acquisition. The relationships between tasks —complementarities (synergies) and substitutability— determine the allocation of knowledge among the members in an organization.

2. Communication shapes the relationship between individual knowledge and governs the organizational process and structure. In particular, horizontal communication of codified knowledge permits the division of labor and knowledge specialization; vertical communication of noncodifiable tacit knowledge allows managers to leverage talent and employ knowledge hierarchies.

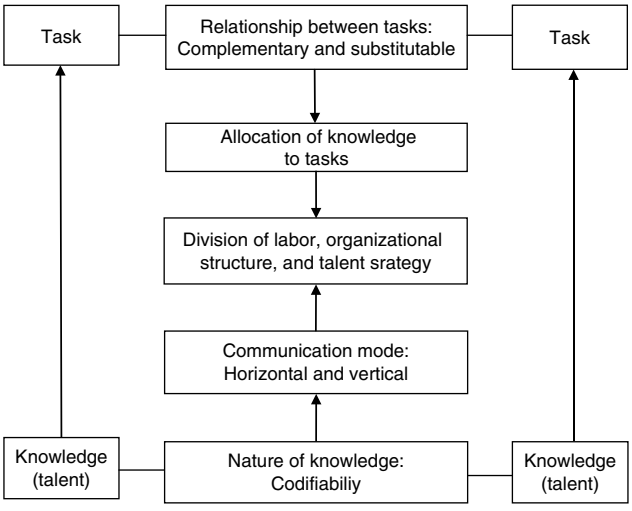
3. Organizational codes can be designed to facilitate communication and knowledge sharing. Organization should be accordingly structured to balance horizontal and vertical communication.

4. In decision making, organizational structure can be deliberately designed ex ante to correct bias and complement the limitation of individual judgment, the extent to which depends on the attributes of tasks and the properties of knowledge.

5. Organizational processes and the routinized organizational structure are the core of organizational capital that generates rent and sustains organizational growth.

The basic theoretical analysis in this paper is based on an expanding body of studies in organizational economics that focuses on the cognitive aspect of organization (see Garicano and Prat 2011 for an updated survey). We have confined our discussion to the traditional team theory framework in which members of an organization share the same objective function. What has been highlighted is the coordination aspect of knowledge management and talent strategy. We leave the incentive concern aside. In future research, we aim to incorporate both the coordination and incentive aspects of organization in the study of organizational strategy and knowledge management.

Figure 3 Task-Based Organizational Structure, Process, and Knowledge Management



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Endnotes

[1]Amit and Schoemaker (1993) do not define organization capital directly. Rather, they define "organizational rents" as economic rents generated by strategic assets.

[2]However, even organizational rents generated by strong complementarities may be dissipated by market competition, as Kremer (1993) shows in his analysis of O-ring production functions.

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