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Source: *Strategic Management Journal*, Vol. 17, Special Issue: Knowledge and the Firm (Winter, 1996), pp. 109-122

Published by: [Wiley](#)

Stable URL: <http://www.jstor.org/stable/2486994>

Accessed: 08/08/2013 17:56

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TOWARD A KNOWLEDGE-BASED THEORY OF THE FIRM

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Given assumptions about the characteristics of knowledge and the knowledge requirements of production, the firm is conceptualized as an institution for integrating knowledge. The primary contribution of the paper is in exploring the coordination mechanisms through which firms integrate the specialist knowledge of their members. In contrast to earlier literature, knowledge is viewed as residing within the individual, and the primary role of the organization is knowledge application rather than knowledge creation. The resulting theory has implications for the basis of organizational capability, the principles of organization design (in particular, the analysis of hierarchy and the distribution of decision-making authority), and the determinants of the horizontal and vertical boundaries of the firm. More generally, the knowledge-based approach sheds new light upon current organizational innovations and trends and has far-reaching implications for management practice.

Theories of the firm are conceptualizations and models of business enterprises which explain and predict their structure and behaviors. Although economists use the term 'theory of the firm' in its singular form, there is no single, multipurpose theory of the firm. Every theory of the firm is an abstraction of the real-world business enterprise which is designed to address a particular set of its characteristics and behaviors (Machlup, 1967). As a result, there are many theories of the firm which both compete in offering rival explanations of the same phenomena, and complement one another in explaining different phenomena.

Economic theories of the firm are concerned primarily with predicting the behavior of firms in external markets. In particular, the neoclassical theory of the firm uses partial equilibrium analysis to predict the firm's purchase decisions in input markets and supply decisions in output markets. Organizational theory addresses aspects of the

firm ignored by neoclassical economics. Disposing of the notion of the firm as a singular decision taker and recognizing the firm as a complex organization encompassing multiple individuals, organization theory analyzes the internal structure of the firm and the relationships between its constituent units and departments.

Interest by social scientists in the firm as an institution has been stimulated by the question of why firms exist at all. Dissatisfaction with Knight's explanation of the firm in terms of optimal risk allocation in the face of individuals' differential risk preferences (Knight, 1921) encouraged the emergence of the transaction cost theory of the firm which focused upon the relative efficiency of authority-based organization ('hierarchies') with contract-based organization ('markets') (Coase, 1937; Williamson, 1975). Attempts at integrating economics and organizational approaches to the theory of the firm have included the behavioral theory of the firm (Cyert and March, 1963) and the evolutionary theory of the firm (Nelson and Winter, 1982).

Although strategic management has drawn its theories of the firm from both economics and

Key words: knowledge; theory of the firm; coordination

CCC 0143-2095/96/S20109-14
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organization theory, its area of interest is different from both. Its primary goals are to explain firm performance and the determinants of strategic choice. The result has been new contributions to the theory of the firm. The resource-based view of the firm is less a theory of firm structure and behavior as an attempt to explain and predict why some firms are able to establish positions of sustainable competitive advantage and, in so doing, earn superior returns. The resource-based view perceives the firm as a unique bundle of idiosyncratic resources and capabilities where the primary task of management is to maximize value through the optimal deployment of existing resources and capabilities, while developing the firm's resource base for the future.

The emerging 'knowledge-based view' is not, as yet, a theory of the firm. There is insufficient consensus as to its precepts or purpose, let alone its analysis and predictions, for it to be recognized as a 'theory.' It represents a confluence of long-established interests in uncertainty and information with several streams of newer thinking about the firm. To the extent that it focuses upon knowledge as the most strategically important of the firm's resources, it is an outgrowth of the resource-based view. At the same time, knowledge is central to several quite distinct research traditions, notably *organizational learning*, the *management of technology*, and *managerial cognition*. The issues with which the knowledge-based view concerns itself extend beyond the traditional concerns of strategic management—strategic choice and competitive advantage—and address some other 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. The purpose of this article is to make progress in developing some key elements of a knowledge-based theory of the firm by synthesizing some of the principal contributions to this emerging field. The paper develops and extends some of the ideas outlined in Grant (1996) into a more general knowledge-based approach to the firm which seeks to:

- explain the existence of the firm as an insitution for the organization of production (third section);

- explore the nature of coordination within the firm (fourth section);
- analyze organizational structure, focusing upon the implications of the knowledge-based view for hierarchy and the location of decision-making authority (fifth section);
- determine the boundaries of the firm (sixth section).

I begin by identifying some characteristics of knowledge and establishing some fundamental assumptions concerning its role within the firm.

FOUNDATIONS

The foundation for any theory of the firm is a set of initial premises which form the basis for the logical development of propositions concerning the structure, behavior, performance and, indeed, the very existence of firms. Developing a knowledge-based theory of the firm raises the issue: *What is knowledge?* Since this question has intrigued some of the world's greatest thinkers from Plato to Popper without the emergence of a clear consensus, this is not an arena in which I choose to compete. In terms of defining knowledge, all I offer beyond the simple tautology of 'that which is known' is the recognition that there are many types of knowledge relevant to the firm.¹ For the purposes of developing a theory of the firm, my primary task is to establish those characteristics of knowledge which have critical implications for management. The literature on the analysis and management of knowledge points to the following characteristics as pertinent to the utilization of knowledge within the firm to create value.²

¹ Machlup (1980) identifies 13 different 'elements of knowing' including: being acquainted with, being familiar with, being aware of, remembering, recollecting, recognizing, distinguishing, understanding, interpreting, being able to explain, being able to demonstrate, being able to talk about, and being able to perform. Machlup also identifies five 'classes of knowledge' including: practical knowledge, intellectual knowledge (embracing scientific, humanistic, and cultural knowledge), pastime knowledge (news, gossip, stories, and the like), spiritual knowledge, and unwanted knowledge.

² A firm can create value in two ways. By *production* inputs are physically transformed into outputs where the outputs have greater value than the inputs. By *arbitrage*, either across place (trade) or time (speculation), firms create value by moving a product from one market to another, but without physically transforming it. In this paper, my focus is upon the role of knowledge among firms which engage in pro-

Transferability

The resource-based view of the firm recognizes the transferability of a firm's resources and capabilities as a critical determinant of their capacity to confer sustainable competitive advantage (Barney, 1986). With regard to knowledge, the issue of transferability is important, not only between firms, but even more critically, within the firm. The management literature has clearly recognized the epistemological distinction between *knowing how* and *knowing about* which is captured by distinctions between subjective vs. objective knowledge, implicit or tacit vs. explicit knowledge, personal vs. propositional knowledge, and procedural vs. declarative knowledge. My purpose here is not to make fine distinctions between different types of knowledge. I identify *knowing how* with *tacit knowledge*, and *knowing about* facts and theories with *explicit knowledge*. The critical distinction between the two lies in transferability and the mechanisms for transfer across individuals, across space, and across time. Explicit knowledge is revealed by its communication. This ease of communication is its fundamental property. Indeed information has traditionally been viewed by economists as being a public good—once created it can be consumed by additional users at close to zero marginal cost. Tacit knowledge is revealed through its application. If tacit knowledge cannot be codified and can only be observed through its application and acquired through practice, its transfer between people is slow, costly, and uncertain (Kogut and Zander, 1992).

Capacity for aggregation

The efficiency with which knowledge can be transferred depends, in part, upon knowledge's potential for *aggregation*. Knowledge transfer involves both transmission and receipt. Knowledge receipt has been analyzed in terms of the *absorptive capacity* of the recipient (Cohen and Levinthal, 1990). At both individual and organizational levels, knowledge absorption depends upon the recipient's ability to add new knowledge to existing knowledge. This requires additivity between different elements of knowledge.

duction, mainly because this is the most important and complex means of value creation.

Efficiency of knowledge aggregation is greatly enhanced when knowledge can be expressed in terms of common language. Statistics is a particularly useful language for aggregating (and transferring) certain types of explicit knowledge—its efficiency in this role is greatly enhanced through advances in information technology. Thus, information on Ford Motor Company's cash balances, its foreign currency exposure, its inventories of spark plugs and crankshafts is readily transferred from multiple locations within the company and aggregated at a single location. Conversely information about the capabilities of Ford managers, or the quirks of individual machine tools, is *idiosyncratic knowledge* which cannot be aggregated at a single location. Hayek (1945: 521) refers to this as 'knowledge of the particular circumstances of time and place,' and Jensen and Meckling (1992) as 'specific knowledge.' As these authors have shown, and as we shall explore later in the paper, the ability to transfer and aggregate knowledge is a key determinant of the optimal location of decision-making authority within the firm.

Appropriability

Appropriability refers to the ability of the owner of a resource to receive a return equal to the value created by that resource (Teece, 1987; Levin *et al.*, 1987). Knowledge is a resource which is subject to uniquely complex problems of appropriability. Tacit knowledge is not directly appropriable because it cannot be directly transferred: it can be appropriated only through its application to productive activity. Explicit knowledge suffers from two key problems of appropriability: first, as a *public* or *nonrivalrous* good, any one who acquires it can resell without losing it (Arrow, 1984); second, the mere act of marketing knowledge makes it available to potential buyers (Arrow, 1971: 152). Thus, except for patents and copyrights where knowledge owners are protected by legally established property rights, knowledge is generally inappropriable by means of market transactions. Lack of clear property rights results in ambiguity over the ownership of knowledge. While most explicit knowledge and all tacit knowledge is stored within individuals, much of this knowledge is created within the firm and is firm specific. This creates difficulties over the allocation of the returns to knowledge and achiev-

ing optimal investment in new knowledge (Rosen, 1991).

Specialization in knowledge acquisition

Fundamental to Simon's principle of bounded rationality is recognition that the human brain has limited capacity to acquire, store and process knowledge. The result is that efficiency in knowledge production (by which I mean the creation of new knowledge, the acquisition of existing knowledge, and storage of knowledge) requires that individuals specialize in particular areas of knowledge. This implies that experts are (almost) invariably specialists, while jacks-of-all-trades are masters-of-none.

The knowledge requirements of production

Production involves the transformation of inputs into outputs. Fundamental to a knowledge-based theory of the firm is the assumption that the critical input in production and primary source of value is knowledge. Indeed, if we were to resurrect a single-factor theory of value in the tradition of the classical economists' labor theory of value or the French Physiocrats land-based theory of value, then the only defensible approach would be a knowledge-based theory of value, on the grounds that all human productivity is knowledge dependent, and machines are simply embodiments of knowledge.

THE EXISTENCE OF THE FIRM

The above precepts establish a rationale for the existence of firms. Following Demsetz (1991: 171–175), the existence of the firm represents a response to a fundamental asymmetry in the economics of knowledge: knowledge acquisition requires greater specialization than is needed for its utilization. Hence, production requires the coordinated efforts of individual specialists who possess many different types of knowledge. Yet markets are unable to undertake this coordinating role because of their failure in the face of (a) the immobility of tacit knowledge and (b) the risk of expropriation of explicit knowledge by the potential buyer. Hence, firms exist as institutions for producing goods and services because they can create conditions under which multiple

individuals can integrate their specialist knowledge. These conditions include propinquity and 'low-powered' incentives designed to foster coordination between individual specialists which avoid the problems of opportunism associated with the 'high-powered' incentives directly related to knowledge transactions.

A possible solution to the inability of markets to contract over transfers of tacit knowledge is to contract over units of workers' time. But even if units of labor time are suitable proxies for the supply of tacit knowledge, so long as production requires the complex integration of multiple types of knowledge within a system of team production, then Rosen (1991) shows that markets must establish an incredibly complex wage structure which sets a separate wage rate for every worker's interaction with every other worker.³

Note that this view of the role of the firm as a knowledge-integrating institution is somewhat different from that emphasized in the literature. Most research into organizational learning (Levitt and March, 1988; Huber, 1991) and the knowledge-based view of the firm (Spender, 1989; Nonaka, 1991, 1994) focuses upon the acquisition and creation of *organizational knowledge*. Thus, Spender (1989: 185) defines 'the organization as, in essence, a body of knowledge about the organization's circumstances, resources, causal mechanisms, objectives, attitudes, policies, and so forth.' My approach is distinguished by two assumptions: first, that knowledge creation is an individual activity; second, that the primary role of firms is in the application of existing knowledge to the production of goods and services. This dispensing with the concept of *organizational knowledge* in favor of emphasizing the role of the individual in creating and storing knowledge is consistent with Simon's observation that: 'All learning takes place inside individual human heads; an organization learns in only two ways: (a) by the learning of its members, or (b) by ingesting new members who have knowledge the organization didn't previously have' (Simon, 1991: 125). More importantly, however, is the desire to understand the organizational processes through which firms access and utilize the knowl-

³ On a simple production process involving n workers, where each worker interacts separately with each other worker, a total of $(n^2-n)/2$ wage rates must be established (Rosen, 1991: 78–81).

edge possessed by their members. The danger inherent in the concept of organizational knowledge is that, by viewing the organization as the entity which creates, stores and deploys knowledge, the organizational processes through which individuals engage in these activities may be obscured. Thus, March views organizations as storing 'knowledge in their procedures, norms, rules, and forms. They accumulate such knowledge over time learning from their members' (March, 1991: 73). This learning process involves 'encoding inferences from history into routines that guide behavior. The generic term *routines* includes the forms, rules, procedures, conventions, strategies, and technologies around which organizations are constructed and through which they operate' (Levitt and March, 1988: 320). Taking the organization as the unit of analysis not only runs the risk of reification, but, by defining rules, procedures, conventions, and norms as knowledge fails to direct attention to the mechanisms through which this 'organizational knowledge' is created through the interactions of individuals, and offers little guidance as to how managers can influence these processes.

Unlike Spender (1992), who analyzes the dual role of firms in knowledge *generation* and knowledge *application*, my emphasis is on the firm as an institution for knowledge application. This is not to deny the importance of organizational context in knowledge creation. If production creation requires the integration of each person's knowledge with that of others, even if knowledge acquisition is individualistic, the firm provides necessary incentives and direction. If knowledge is specific to a particular team production process, then knowledge creation cannot be separated from knowledge application—both occur within a common organizational context. Thus, if the members of Manchester United soccer team have complementary skills, then they need to be tied together by long-term relationships in order to achieve the investment in team-based skills required to maximize team performance. Market contracts are unlikely to achieve the stability of long-term relationships and are likely to give rise to all the problems of opportunism that transactions cost economics predicts are a consequence of small numbers and transaction-specific investments.

This rationale for the existence of the firm may be criticized as being a special case of the

Coase/Williamson transaction cost theory of the firm. Firms exist because they are able to avoid the costs associated with market transactions; the knowledge-based view simply focuses upon the costs associated with a specific type of transaction—those involving knowledge. Certainly, the above analysis draws upon some familiar concepts of market failure. However, the key distinction is emphasis upon the firm as an organization for managing team production rather than an institution for managing transactions. In common with the arguments of Ghoshal and Moran (1996), the central advantage of firms in the production process is not simply an avoidance of the transactions costs associated with market exchange, but their 'unique advantages for governing certain types of economic activities from a logic that is very different from that of a market' (Ghoshal and Moran, 1996: 13). Integrating the knowledge of many different individuals in the process of producing goods and services is such a logic. To develop this argument further, these processes for integrating knowledge need to be specified more clearly.

COORDINATION WITHIN THE FIRM

The assumptions that there are gains from specialization in knowledge acquisition and storage, and that production requires the input of a wide range of specialized knowledge, restates a premise which, either explicitly or implicitly, is fundamental to all theories of the firm. Without benefits from specialization there is no need for organizations comprising multiple individuals. Given the efficiency gains of specialization, the fundamental task of organization is to coordinate the efforts of many specialists. Although widely addressed, organization theory lacks a rigorous integrated, well-developed and widely agreed theory of coordination.

Comparative neglect of the mechanisms through which individuals integrate their productive activities reflects organization theory's preoccupation, not with coordination *per se*, but with the problems of *cooperation* which arise from reconciling and subordinating the disparate goals of organizational members. Thus, Lawrence and Lorsch (1967), building upon the ideas of March and Simon (1958) and Selznick (1948), viewed coordination as the resolution of intraor-

ganizational goal conflict, while the institutional economics literature has been dominated by the problems of the divergence of employee and owner goals causing problems of agency (Jensen and Meckling, 1976), shirking (Leibenstein, 1966; Alchian and Demsetz, 1972) and opportunism (Williamson, 1975).

Consistent with this emphasis, organization theory's focus upon hierarchy as the basic structure for organizing complex social activity has concentrated upon *authority relations* where cooperation is achieved through vertically imposed bureaucratic processes. Later writers identified multiple mechanisms for coordination within organizations. Ouchi (1979) identified three types of coordination mechanism: market mechanisms, bureaucratic mechanisms, and clan mechanisms.

The knowledge-based literature has, so far, had only limited impact on the analysis of coordination. Research into organizational learning and management of technology has explored the transfer and diffusion of knowledge within organizations (e.g., Kay, 1979; Levitt and March, 1988; Boisot, 1995), but has made only limited progress in addressing the fact that, if most of the knowledge relevant to production is tacit, then transfer of knowledge between organizational members is exceptionally difficult. Nonaka (1994) emphasizes the *conversion* of tacit into explicit knowledge (and vice versa), while Brown and Duguid (1991) stress the role of *communities-of-practice* in providing common structure and meaning for the transfer of experience.

But *transferring* knowledge is not an efficient approach to *integrating* knowledge. If production requires the integration of many people's specialist knowledge, the key to efficiency is to achieve effective integration while minimizing knowledge transfer through cross-learning by organizational members. If Grant and Spender wish to write a joint paper together, efficiency is maximized not by Grant learning everything that Spender knows (and vice versa), but by establishing a mode of interaction such that Grant's knowledge of economics is integrated with Spender's knowledge of philosophy, psychology and technology, while minimizing the time spent transferring knowledge between them.

Viewing the firm's primary task as integrating the specialized knowledge of multiple individuals suggests that, even with goal congruence, achiev-

ing effective coordination is problematic for organizations. The literature addressing integration across specialized organizational units has viewed coordination as dependent upon the characteristics of the process technology deployed. Thus, Thompson identified three types of interdependence, *pooled*, *sequential*, and *reciprocal*, to which Van de Ven, Delbecq, and Koenig (1976) added a fourth, *team* interdependence. The type of interdependence within a task determines the mode of coordination deployed. Pooled interdependence calls for coordination by *rules*, sequential interdependence can be effectively coordinated by *plans*, reciprocal interdependence is associated with *mutual adjustment*, while team interdependence requires *group coordination*, through scheduled and unscheduled meetings (Thompson, 1967; Van de Ven *et al.*, 1976).

A knowledge-based view of the firm encourages us to perceive interdependence as an element of organizational design and the subject of managerial choice rather than exogenously driven by the prevailing production technology. The general issue is devising mechanisms for integrating individuals' specialized knowledge. While process technology defines the technical aspects of production and the types of specialized knowledge required for the process, the division of tasks between individuals and departments and the specification of the interfaces between them lies within the domain of organizational design.

Integrating the literature on formal and explicit coordination mechanisms with that on informal and implicit coordination processes, and relating this to characteristics and role of knowledge, points to four mechanisms for integrating specialized knowledge:

1. *Rules and directives*. 'Impersonal': approaches to coordination involve 'plans, schedules, forecasts, rules, policies and procedures, and standardized information and communication systems' (Van de Ven *et al.*, 1976: 323). Rules may be viewed as standards which regulate the interactions between individuals. Thus, in society at large, rules in the form of etiquette, politeness and social norms are essential to facilitating human interaction. The efficiency of these mechanisms in achieving coordination extends beyond their ability to minimize communication (Galbraith, 1973). As recognized by Demsetz (1991) *direction* is a 'low cost

method of communicating between specialists and the large number of persons who either are non-specialists or who are specialists in other fields' (Demsetz, 1991: 172). Such rules are directives provide a means by which tacit knowledge can be converted into readily comprehensible explicit knowledge. Thus, it is highly inefficient for a quality engineer to teach every production worker all that he knows about quality control. A more efficient means of integrating his knowledge into the production process is for him to establish a set of procedures and rules for quality control.

2. *Sequencing.* Probably the simplest means by which individuals can integrate their specialist knowledge while minimizing communication and continuous coordination is to organize production activities in a time-patterned sequence such that each specialist's input occurs independently through being assigned a separate time slot. Thompson viewed sequential interdependence as technologically determined. Certainly, the characteristics of the product, its physical inputs, and its production technology strongly influence the potential for sequencing: a product comprised of multiple components facilitates sequencing much more than a commodity produced by continuous processes. However, in most production activities there is discretion over the extent of sequencing. For example, new product design can be fully sequential, overlapping sequences, or concurrent (Nonaka, 1990; Clark and Fujimoto, 1992).
3. *Routines.* An organizational routine is a 'relatively complex pattern of behavior ... triggered by a relatively small number of initiating signals or choices and functioning as recognizable unit in a relatively automatic fashion' (Winter, 1986: 165). While routines may be simple sequences, their interesting feature is their ability to support complex patterns of interactions between individuals in the absence of rules, directives, or even significant verbal communication. To this extent, routines embody Thompson's notion of coordination by mutual adjustment. There are two main dimensions to this complexity. First, routines are capable of supporting a high level of simultaneity of individuals' performance of their particular tasks—examples include navigation of a ship (Hutchins, 1991), surgical

operating teams and auto racing pit crews (Grant, 1996), and the operations of fast food restaurants (Leidner, 1993). Second, routines can permit highly varied sequences of interaction. While Nelson and Winter (1982) and Gersick and Hackman (1990) have emphasized the automatic nature of routines, Pentland and Rueter (1994) have shown that a routine can be a varied repertoire of responses in which individuals' moves are patterned as 'grammars of action.'

4. *Group problem solving and decision making.* While all the above mechanisms seek efficiency of integration through avoiding the costs of communication and learning, some tasks may require more personal and communication-intensive forms of integration. Galbraith (1973) points to the need for 'impersonal' coordination through rules and plans to be supplemented by 'personal' and 'group' coordination modes, the last taking the form of meetings. Reliance upon high-interaction, nonstandardized coordination mechanisms increases with task complexity (Perrow, 1967) and task uncertainty (Galbraith, 1973; Van de Ven *et al.*, 1976). Hutchins (1991) documents the switch from routine-mode to group problem-solving mode in a crisis. The main contribution of the knowledge-based view to this discussion is recognition of the high costs of consensus decision making given the difficulties of communicating tacit knowledge. Hence, efficiency in organizations tends to be associated with maximizing the use of rules, routines and other integration mechanisms that economize on communication and knowledge transfer, and reserve problem solving and decision making by teams to unusual, complex, and important tasks.

The role of common knowledge

While these mechanisms for knowledge integration are necessitated by the differentiation of individuals' stocks of knowledge, all depend upon the existence of *common knowledge* for their operation. At its most simple, common knowledge comprises those elements of knowledge common to all organizational members: the intersection of their individual knowledge sets. The importance of common knowledge is that it permits individuals to share and integrate aspects of knowledge

which are *not* common between them. Common knowledge has some similarities with Nonaka and Takeuchi's *redundancy*: 'information that goes beyond the operational requirements of organizational members,' which permits 'individuals to invade one another's functional boundaries' and provides 'individuals ... loosely coupled with each other ... a self-control mechanism' (Nonaka and Takeuchi, 1995: 80–81). Different types of common knowledge fulfill different roles in knowledge integration:

- *Language*. The existence of a common language is fundamental to integration mechanisms which rely upon verbal communication between individuals, namely, integration through rules and directives, and integration through group problem solving and decision making. The lack of a common language among workers in many U.S. plants and other polyglot organizations is a significant barrier to the introduction of integration-intensive manufacturing techniques.
- *Other forms of symbolic communication*. A single tongue is but one aspect of commonality of language. If language is defined to embody all forms of symbolic communication then literacy, numeracy, and familiarity with the same computer software are all aspects of common language which enhance the efficiency and intensity of communication. Companies such as Motorola and Texas Instruments show that investments in literacy, numeracy and basic statistics which raise the level of employees' common knowledge increase the effectiveness of rules, directives, and meetings in implementing sophisticated levels of TQM.
- *Commonality of specialized knowledge*. While language provides a common platform for communication-based modes of knowledge, the level of sophistication which communication-based modes of knowledge integration achieve depends upon the extent of commonality in their specialized knowledge. There is something of a paradox in this. The benefit of knowledge integration is in meshing the different specialized knowledge of different individuals—if two people have identical knowledge there is no gain from integration—yet, if the individuals have entirely separate knowledge bases, then integration cannot occur beyond the most primitive level.
- *Shared meaning*. The problem of communication-based modes of knowledge integration is

that they require the conversion of tacit knowledge into explicit form. Such conversion typically involves substantial knowledge loss. However, tacit knowledge can be communicated through the establishment of shared understanding between individuals. Polanyi (1966: 61) notes that 'a teaching which appears meaningless to start with has in fact a meaning which can be discovered by hitting on the *same kind of indwelling* as the teacher is practicing' (emphasis added). The organizational learning literature points to the role of common cognitive schema and frameworks (Weick, 1979; Spender, 1989), metaphor and analogy (Nonaka and Takeuchi, 1995: 64–67), and stories (Brown and Duguid, 1991) as vehicles for molding, integrating and reconciling different individual experiences and understandings. More generally, Leudar (1992) explores the role of mutual cognitions in coordinating social actions.

- *Recognition of individual knowledge domains*. Shared understanding facilitates coordinated activity, but effective knowledge integration also requires that each individual is aware of everyone else's knowledge repertoire. 'Reciprocal' or 'group' interdependence, such as that occurring within a soccer or debating team, necessitates coordination by *mutual adjustment* (Thompson, 1967: 56). Achieving this without explicit communication requires that each team member recognizes the abilities of other team members. Such mutual recognition permits successful coordination even in novel situations.

Organizational capability

This analysis of the firm as an integrator is especially helpful to the analysis of organizational capabilities. Grant (1996) views organizational capability as the outcome of knowledge integration: complex, team-based productive activities such as American Express's customer billing system, Chrysler's automobile design process, and Shell's deep-sea oil exploration, are dependent upon these firms' ability to harness and integrate the knowledge of many individual specialists.

This analysis of organizational capability offers insight into the linkage between organizational capability and competitive advantage. The extent to which a capability is 'distinctive' depends upon

the firm accessing and integrating the specialized knowledge of its employees. If employees are mobile, organizational capability depends more upon the firm's mechanisms of integration rather than the extent of specialist knowledge which employees possess. The higher the level and sophistication of common knowledge among the team, whether in the form of language, shared meaning, or mutual recognition of knowledge domains, the more efficient is integration likely to be. The shift in employee training from deepening of specialist skills towards increased cross-training and job rotation is based on the belief that trading off increased common knowledge against decreased specialist knowledge will enhance organizational capabilities.

Longevity of competitive advantage depends upon the inimitability of the capabilities which underlie that advantage. The broader the scope of the knowledge integrated within a capability, then the more difficult limitation becomes. The complexity of 'broad-scale' integration creates greater causal ambiguity and greater barriers to replication. The dilemma for managers is that organizational capabilities which require greater breadth of knowledge will show lower levels of common knowledge between team members. Current interest in cross-functional capabilities such as new product development (Clark and Fujimoto, 1992), fast response capability (Stalk, 1988), 'architectural innovation' (Henderson and Clark, 1990) reflects the strategic importance and managerial challenge of capabilities which require effective integration of many disparate specialists.

ORGANIZATIONAL STRUCTURE

The above assumptions about knowledge and the conceptualization of the firm as a knowledge-integrating institution have two main implications for the internal structure of the firm: first, the role of hierarchy; second, the location of decision making.

Implications for hierarchy

The fundamental organizational problem is achieving purposeful, coordinated action from organizations comprising many individuals. As noted above, there are two dimensions to this problem: first, the pure coordination problem;

second, the cooperation problem. Even if the technical problem of coordination can be solved, how are the divergent goals of individuals resolved? Hierarchy has emerged as an efficient solution to both. Aoki (1990) observes that one of the differences between U.S. and Japanese corporations is that, while the hierarchies of Western firms combine the roles of cooperation and coordination, Japanese hierarchies exist primarily to provide the incentive structures to support cooperation, but coordination occurs outside the formal hierarchy.

As observed earlier, within organization theory, analysis of hierarchy has concentrated upon the problem of cooperation. The preoccupation with organizations as hierarchies of *authority* reflects the organizational antecedents of business corporations: churches existed to impose the authority of God, government departments to impose the authority of the monarch or (in democracies) the people, while the effectiveness of armies and navies required the authority to send men to their deaths.

The analysis of hierarchy as a coordination mechanism has been associated with cybernetics and systems theory. Simon (1981) argues that hierarchy is a general feature of complex systems emerging because of its evolutionary and problem-solving advantages. Hierarchy is an efficient mechanism for coordinating a complex system comprising multiple specialized units. Business firms are examples of hierarchies since they are 'composed of interrelated sub-systems, each of the latter being in turn hierarchic in structure until we reach some lowest level of elementary subsystem' (Simon, 1981: 196). Using simple models of information processing, Radner (1992) derives principles and algorithms for the optimal design of hierarchies.

Simon (1981) identifies intensity of interaction as the basis for organizing hierarchy: at every level, interaction within the substructure is more intense than between the substructures. This property permits *near decomposability*—for most aspects of their functioning each unit may be viewed as operating autonomously. Thompson (1967: 57–61) uses this principle of grouping by intensity of interaction to propose that organizations should structure their hierarchies by group in, first, those individuals who are *reciprocally interdependent*, and subsequently individuals subject to *sequential* and pooled *interdependence*.

These approaches to hierarchical coordination involve assumptions about the forms of knowledge being utilized within organization: typically that hierarchies are involved in the processing of information. Once firms are viewed as institutions for integrating knowledge, a major part of which is tacit and can be exercised only by those who possess it, then hierarchical coordination fails. Consider the design of a new range of cosmetics. Within the marketing department different market researchers, brand managers, advertising executives, and sales representatives each have valuable insights into the market opportunity for a new cosmetic range, the desirable characteristics of such a range, the profiles of potential purchasers, and the appropriate marketing of such a range. Within R&D expertise about the technical opportunities for using new materials and developing innovative characteristics in cosmetics is distributed among specialists in botany, fatty acids, emulsification, perfumes, and polymer science. If new product design requires integrating marketing know-how and technical know-how, how can meetings between the marketing VP and technology VP achieve this if the required knowledge is distributed among their subordinates? When managers know only a fraction of what their subordinates know and tacit knowledge cannot be transferred upwards, then coordination by hierarchy is inefficient.

Only one of the integration mechanisms identified in the previous section is compatible with hierarchy: integration through rules and directives. Indeed, the bureaucratic systems typically associated with organizational hierarchies rely heavily upon rules and directives. However, their basis is different in the knowledge-based model from the traditional bureaucratic model. In a bureaucracy rules and directives are vehicles for the exercise of authority. They emanate from the source of authority in the organization and apply top down. In the knowledge-based firm, rules and directives exist to facilitate knowledge integration; their source is specialist expertise which is distributed throughout the organization.

Many current trends in organizational design can be interpreted as attempts to access and integrate the tacit knowledge of organizational members while recognizing the barriers to the transfer of such knowledge. While analysis of delayering has concentrated upon cost reduction and increasing the speed of decision making, the

knowledge-based view suggests that, to the extent that 'higher-level decisions' are dependent upon immobile 'lower-level' knowledge, hierarchy impoverishes the quality of higher-level decisions. The dilemma is this: if production (and decisions about production) require many types of knowledge, if that knowledge is resident in many individuals, and if integration mechanisms can involve only relatively small numbers of individuals—what organizational structures are possible?

The recent vogue for team-based structures where team membership is fluid, depending upon the knowledge requirements of the task at hand, is one response to the deficiencies of hierarchy. The essence of a team-based organization is recognition that coordination is best achieved through the direct involvement of individual specialists and that specialist coordinators ('managers') cannot effectively coordinate if they cannot access the requisite specialist knowledge. The spread of team organization throughout production activities recognizes that critical know-how is located among individual operatives—specialists. The displacement of scientific management by various forms of participative, employee-empowering management approaches partly reflects the motivational benefits of these systems, but is also a result of the greater efficiency of these systems in accessing and integrating the relevant knowledge. Wruck and Jensen (1994) identify *total quality management* as a nonhierarchical, team-based organizing technology that permits an organization to access and utilize individuals' knowledge located at low levels of the organization.

In 'higher-level' integration—cross-functional coordination for example—barriers to vertical knowledge transfer imply that integration requires the direct participation of specialists. Hence, the trend in new product development has been away from sequential processes coordinated by the heads of functional departments towards cross-functional teams. The key problem with such teams is, given coordination restricts their size, teams are unable to directly access the full range of specialist knowledge relevant to their activities. This can be partially addressed by making their membership fluid so that relevant expertise can be tapped when needed.

More generally, if movement of knowledge within the organization requires the movement

of the specialists who possess it, then effective knowledge utilization will tend to require that individuals occupy multiple organizational roles involving membership of multiple teams.

Implications for the distribution of decision-making authority in the firm

Implications for the allocation of decision-making authority in the firm follow directly from the above discussion of the problems of hierarchical structures in integrating knowledge. The conventional basis for the analysis of decision making is *delegation*. Decision-making rights reside in the owners of the firm. As representatives of owners, the board of directors confers decision-making powers on senior management, which in turn delegates authority down the hierarchy. Agency theory provides a rigorous analysis of the problems of divergent individual goals and the creation of incentive structures to achieve goal alignment (Jensen and Meckling, 1976).

The knowledge-based view of the firm has two principal implications for the distribution of decision making. The first issue concerns the linkage between decision rights and ownership. If the primary productive resource of the firm is knowledge, and if knowledge resides in individual employees, then it is employees who own the bulk of the firm's resources. The firm contracts with employees for the use of these knowledge resources. However, unlike physical and financial assets, employment contracts confer upon the firm only partial and ill-defined ownership rights over employees' knowledge assets. Moreover, the decision rights of the firm in relation to employees' knowledge are severely constrained. Knowledge assets remain resident within individual employees and cannot be readily transferred. If decision rights are conferred by ownership and if the firm's resources are jointly owned by stockholders and employees—then management's decision rights are delegated downwards by the stockholders and board of directors, and upwards by employees. Thus, the knowledge-based firm corresponds more closely to Aoki's (1990) analysis of the Japanese corporation as a system of dual control jointly exercised by stockholders and employees, than it does to the conventional shareholder-owned and controlled corporation which dominates the Anglo-Saxon capitalist tradition.

The second issue concerns co-location of

decision making and knowledge. The quality of decisions depends upon their being based upon relevant knowledge. If the knowledge relevant to a particular decision can be concentrated at a single point in the organization, then centralized decision making is feasible. But the ability to transfer and aggregate knowledge varies between different types of knowledge. Explicit knowledge is transferable, but cannot necessarily be aggregated at a single point. Jensen and Meckling's *specific knowledge* is knowledge which is costly to transfer; this would comprise both tacit knowledge and explicit knowledge which cannot be aggregated and analyzed in statistical form. The principle of co-location requires that decisions based upon such tacit and idiosyncratic knowledge are decentralized, while decisions requiring statistical knowledge are centralized.

Recent organizational changes in the oil and gas industry illustrate these tendencies (Grant and Cibin, 1996). Decisions which require accessing and processing quantifiable information have become increasingly centralized—treasury and financial risk management functions for example. Decisions requiring tacit and idiosyncratic knowledge—strategic planning, investment appraisal, and operational decisions concerning individual oil and gas fields—have become increasingly decentralized.

BOUNDARIES OF THE FIRM

If firms exist to integrate the specialized knowledge possessed by a number of individuals because such integration cannot be performed efficiently across markets, what determines the boundaries of the firm? In the light of the initial assumptions about knowledge, the vertical and horizontal boundaries may be analyzed in terms of relative efficiency of knowledge utilization.

The analysis of vertical boundaries follows Demsetz (1991). If markets transfer products efficiently but transfer knowledge inefficiently (for the reasons outlined earlier), vertically adjacent stages of production A and B will be integrated within the same firm if production at stage B requires access to the knowledge utilized in stage A. If, on the other hand, the output of stage A can be processed at stage B without the need to access the knowledge utilized at stage A, then stages A and B are efficiently conducted by

separate firms linked by a market interface. The dependence of the design of mainframe computers upon the characteristics of integrated circuits (ICs) meant that during the 1960 and 1970s most computer manufacturers were backward integrated into ICs. Within ICs, vertical integration between design and manufacture depends upon the extent to which intense technical dialogue is required between design and fabrication stages. 'Fab-lessness' occurs mainly in digital logic ICs where knowledge separation between design and manufacture is feasible (Monteverde, 1995).

The horizontal boundaries between firms are also likely to occur at gaps occurring between constellations of products and knowledge. The benefits of specialization in knowledge acquisition, the many types of knowledge required to produce a product, and the difficulty of integrating these knowledge inputs across markets, suggest that single-product firms will tend to predominate. The problem is that much knowledge is not product specific and is subject to economies of scope. Hence efficient knowledge utilization requires multiproduct firms. As Grant and Baden-Fuller (1995) argue, firms may be characterized both as product domains and knowledge domains. Efficient knowledge utilization requires congruence between the knowledge domain of the firm and its product domain. Typically, perfect congruence does not exist: the firm's knowledge is not fully deployed by the products it supplies, and the knowledge required by the products supplied is not entirely available from within the firm. Firms tend to form around product-knowledge constellations. Thus, an input-output matrix of knowledge inputs and product outputs for the economy would display broad product-knowledge clusters which correspond to industries within which smaller clusters correspond to individual firms. Imperfect congruence between firms' product and knowledge domains creates opportunities for knowledge trading to achieve fuller utilization of knowledge. Such knowledge trading tends to take place through strategic alliances.

CONCLUSION

Starting from assumptions about the characteristics of knowledge and the requirements of production, this paper identifies the primary role of the firm as integrating the specialist knowledge

resident in individuals into goods and services. The primary task of management is establishing the coordination necessary for this knowledge integration. The main implications of the paper stem from this analysis of coordination. While organization theory has tended to concentrate upon the problems of achieving *cooperation*, the complexities of knowledge integration, especially when tacit knowledge is involved, point to the fact that, even in the absence of goal conflict, coordination is not a trivial issue. When different types of knowledge vary considerably in their potential for transfer and aggregation, the implications for organizational structure and the location of decision-making authority are profound. The principles of organization design suggested by the knowledge-based approach conflict with those of other organizational models, particularly the bureaucratic and information-processing approaches. An interesting feature of the knowledge-based approach is that it offers a theoretical basis for understanding a number of recent organizational innovations and trends. These include the renovation of traditional organizational structures through delayering and empowerment and the development of new organizational forms including horizontal and team-based structures and interfirm alliances. The knowledge-based approach also calls into question other contemporary trends in corporate management. The primary driving force behind corporate restructuring and strategic change has been the quest for shareholder value maximization and enhanced shareholder power. If the primary resource of the firm is knowledge, if knowledge is owned by employees, if most of this knowledge can only be exercised by the individuals who possess it—then the theoretical foundations of the shareholder value approach are challenged.

An important difference between this knowledge-based analysis and other organizational theories (including organizational economics) is the emphasis which the knowledge-based view gives to the firm as an institution for the production of goods and services. Sociology-based theories of organizations tend to analyze organization as institutions for collective social action without distinguishing economic organizations, from those which exist for social, political, and religious ends. It is the task of production through the transformation of inputs into outputs where the issues of creating, acquiring, storing and

deploying knowledge are the fundamental organizational activities. By contrast, the organizational problem common to all forms of social organization is that of cooperation: reconciling the conflicting goals of organizational members. This too has been the emphasis of most economic theories of organization. Both transaction cost economics and agency theory regard the primary organizational problem as the incompatibility of individual goals. It is in the analysis of coordination within the firm that the knowledge-based view promises to make its biggest contribution.

The emphasis on 'promise' rather than achievement points towards the limited progress made so far in building the knowledge-based theory of the firm. This paper has attempted to counterbalance the emphasis of the earlier literature on knowledge creation and organizational knowledge by placing emphasis upon knowledge application and the role of the individual. The emphasis upon the role of the individual as the primary actor in knowledge creation and the principal repository of knowledge, I believe, is essential to piercing the veil of organizational knowledge and clarifying the role of organizations in the creation and application of knowledge. The focus upon knowledge application and disregard for knowledge creation is a more serious limitation. Clearly, a more comprehensive knowledge-based theory of the firm will embrace knowledge creation and application.

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