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GENERIC KNOWLEDGE STRATEGIES IN THE U.S. PHARMACEUTICAL INDUSTRY

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The purpose of this study is to identify groups of firms with similar generic knowledge strategies, determine how these strategies change over time, and compare profit margins of the groups. Knowledge strategies of 21 U.S. pharmaceutical firms are analyzed from 1977 to 1991. Cluster analysis is used to group firms over different time periods based on: (a) balance between internal and external learning, (b) preference for radical or incremental learning, (c) learning speed, and (d) breadth of knowledge base. Our findings indicate that there are four generic knowledge strategy groups: 'Explorers', 'Exploiters', 'Loners', and 'Innovators'. Most firms remain in the same knowledge group over time. The firms in the 'Innovator' and 'Explorer' groups tend to be more profitable than the firms in the 'Exploiter' and 'Loner' groups.

The knowledge-based view of the firm identifies the primary rationale for the firm as the creation and application of knowledge (Demsetz, 1991; Nonaka, 1994; Spender, 1994; Grant, 1996). Performance differences between firms are a result of their different knowledge bases and differing capabilities in developing and deploying knowledge. The management of knowledge can be considered the preeminent dynamic capability of the firm and the principal driver of all other competencies and capabilities (Lei, Hitt, and Bettis, 1996).

Most of the research in this area has investigated the properties of different types of knowledge, in particular the distinction between tacit and explicit knowledge, and the relationship between individual and social knowledge (Nonaka, 1994; Spender, 1994). These differences have critical strategic implications not only for innovation but also for barriers to imitation and the sustainability of competitive advantage (Winter, 1987; Kogut and Zander, 1992).

If knowledge and its management are so important a determinant of firm performance, then knowledge strategies are likely to be a critical area of strategic choice for the firm. In this paper we explore firms' choices of knowledge strategies within the U.S. pharmaceutical industry. We look for evidence of generic knowledge strategies within the industry, examining the characteristics of these strategies and their performance consequences.

KNOWLEDGE STRATEGIES

There are several strategic choices that managers make that shape and direct the organization's learning process and, subsequently, determine the firm's knowledge base. Specifically, our review of the organizational learning and related literatures identified four basic trade-offs that require strategic decisions. These decisions can be either explicitly declared by top management or implicitly implied by their actions regarding the

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allocation of resources and the establishment of different customs, goals, procedures and incentive systems. (1) Firms need to find the proper balance between internal and external learning (Cohen and Levinthal, 1990; Grant, 1996; Chesbrough and Teece, 1996; Bierly and Hämäläinen, 1995). (2) They need to decide to focus more on either radical or incremental learning (March, 1991; Argyris and Schon, 1978; Lant and Mezias, 1992). (3) The optimal speed of learning needs to be decided (Levinthal and March, 1981; Lounamaa and March, 1987; March, 1991; Herriott, Levinthal, and March, 1985; Volberda, 1996). (4) Firms need to find the proper balance between the depth and breadth of their knowledge base (Leonard-Barton, 1995; Henderson and Cockburn, 1994; Hamel and Prahalad, 1994; Hedlund, 1994). The collective responses to these four strategic choices form what we refer to as the firm's knowledge strategy.

External vs. internal learning

A strategic choice for firms is to determine the balance of internal and external learning that best meets their needs and fits their resources. Internal learning occurs when members of the organization generate and distribute new knowledge within the boundaries of the firm. External learning occurs when boundary spanners bring in knowledge from an outside source via either acquisition or imitation and the knowledge is then transferred throughout the organization. An intermediate situation is when learning occurs via some type of strategic alliance where members of the partner organization assist in the transference of knowledge. Focusing more on internal learning will allow the firm to develop its own core competencies and appropriate more profits. For knowledge areas that are fundamentally systemic (complexly integrated with other knowledge areas), firms should focus more on internal learning than external learning so that they have more control over the development process and can better understand the tacit nature of the knowledge (Chesbrough and Teece, 1996). It is very difficult, if not impossible, to acquire knowledge that is mostly tacit from another company.

However, external learning is required for the firm to develop a broader knowledge base and to keep abreast of cutting-edge technologies. Access to a broader knowledge base through external learning increases the flexibility of the firm, which is critical to firms in a dynamic environment (Grant, 1996). Also, internal learning and external learning are mutually interdependent and complementary processes. Cohen and Levinthal (1990) described how firms must excel at internal learning and develop 'absorptive capacity' before they can learn from external sources. Absorptive capacity can be increased by internal R&D in the specific area, production experience, and advanced technical training (Cohen and Levinthal, 1990). On the other hand, the internal learning process can be substantially improved by effective external learning, since there will, obviously, be many new ideas generated outside of the firm. In addition, external learning will enable firms to view some issues from different perspectives, which may be difficult to do with only internal learning due to established organizational routines and biases. Thus, internal and external learning are both vital to the success of the firm and there exists a trade-off between the two. Each firm must determine what is the proper balance between internal and external learning for the firm to maximize its overall learning.

Radical vs. incremental learning

Part of a firm's knowledge strategy is to determine the radicalness of its learning. This concept is related to innovation radicalness, which has been discussed by others (e.g., Tushman and Anderson, 1986), but is different in the sense that we are more interested in the radicalness of the learning process than the end product. The issue is whether it is best for the firm to pursue radical learning that questions and changes the firm's basic assumptions (what Argyris and Schon, 1978, refer to as double-loop learning) or to pursue incremental learning that gradually expands the firm's current knowledge base. Again, the firm faces a trade-off in the sense that incremental learning, or exploitation of current knowledge, may be most effective in the short run, but radical learning, or exploration, is required to be successful in the long run (March, 1991). Firms that focus too much on exploration typically suffer the costs of experimentation without harvesting many of its benefits; but firms that focus too much on exploitation typically find themselves trapped in suboptimal stable equilibria (March, 1991). However, it is difficult to be successful at both because, besides the fact that there are limited resources, in general, a different type of organizational culture and structure is needed for each of these types of learning (Volberda, 1996; Hedlund, 1994).

Learning speed

Firms also need to determine how important it is for them to rapidly learn and apply new knowledge. Implicitly, this decision follows the decision concerning the degree of internal and external learning because, in general, the internal learning process is faster than the external learning process (Bierly and Chakrabarti, 1996). External learning is often slower because (a) there is no internal champion, (b) it may be difficult to interpret and understand the external knowledge, and (c) the 'not invented here' syndrome may be a substantial barrier. Related to determining the importance of learning speed is determining the amount of resources that will be allocated to speeding up both the internal and external learning processes. In general, firms want to maximize learning speed so they can utilize first-in advantages. However, learning too fast and committing oneself to a specific knowledge trajectory may be disastrous if one ends up on the 'wrong branch of the tree' (Levinthal and March, 1981). During a situation where environmental signals are ambiguous and complicate the learning process, it is often better to learn at a slower rate to ensure reliability (Lounamaa and March, 1987; Herriott, Levinthal, and March, 1985). Once a knowledge trajectory is established, it may be difficult to switch to a different trajectory because the firm may be too far behind competitors in the other area and it may be difficult to garner internal support to change, especially if the current learning path has experienced at least moderate success (March, 1991). In addition, slower learning may allow complementary knowledge streams to progress together, allowing for better integration and, in the end, superior collective knowledge.

Breadth of knowledge base

The final element of a firm's knowledge strategy is the decision of how broad or narrow the firm's knowledge base should be. With limited resources, it is usually best to focus on specific domains of knowledge (core competencies) so that you can become leaders in those areas. Hamel and Prahalad (1994) illustrated the strategic importance of developing core products and a depth in a few critical knowledge areas. However, with a broader knowledge base the firm will be in a better position to combine related technologies in a more complex manner. According to Reed and DeFillipi (1990), the combining of different technologies creates causal ambiguity, which increases the sustainability of competitive advantages. Also, as Leonard-Barton (1995) has pointed out, if a firm's knowledge base is too narrow, its core capabilities are likely to evolve into core rigidities since the firm lacks the ability to be adaptive to advances in different but related fields. A broader knowledge base results in increased strategic flexibility and adaptability to environmental changes (Volberda, 1996).

In two other studies of the pharmaceutical industry, Henderson and Cockburn (1994) and Pisano (1994) concluded that the ability to integrate different knowledge streams and competence in a discipline are linked to higher performance. Specifically, Henderson and Cockburn (1994) concluded that 'architectural competence—the skill of integrating a wide range of disciplines—and specific expertise in any of these disciplines provide a source of advantage in drug research productivity. They emphasized that the integration of different knowledge streams is critical both when two internal areas of expertise are combined and when an area of expertise is combined with an external source. Pisano (1994) illustrated the importance of integrating knowledge across different stages of the new drug manufacturing process. A broader knowledge base is integral to the successful integration of different knowledge areas in each of these different examples.

PURPOSE OF STUDY

Organizational configurations assist researchers in understanding the complexity associated with organizations by the identification of distinct sets of firms that demonstrate internal consistency across a variety of areas (Mintzberg, 1990; Miller and Friesen, 1984; Meyer, Tsui, and Hinings, 1993). In the strategic management field, the configurational approach has led to substantial advances by the introduction of generic strategy typologies (e.g., Miles and Snow, 1978; Porter, 1980), strategic archetypes (e.g., Miller and Friesen, 1978), and strategic groups (Caves and Porter, 1977; McGee and Thomas, 1986). Each of these typologies and taxonomies have enhanced the understanding of complex phenomena that would not have been uncovered if the entire industry was analyzed as a whole.

Traditionally, an assumption of the configurational approach is the concept of equifinality (Meyer, Tsui, and Hinings, 1993). However, many reseachers have not accepted this notion and have attempted to identify a superior ideal configuration either for all industries or for a unique setting. But studies attempting to link financial performance with the Miles and Snow typology (e.g., Hambrick, 1983; Zajac and Shortell, 1989), the Porter typology (e.g., Miller and Friesen, 1986; White, 1986), and strategic groups (e.g., Cool and Schendel, 1987; Fiegenbaum and Thomas, 1990) have yielded inconclusive and contradictory results.

The purpose of this exploratory study is to empirically derive a generic knowledge strategy taxonomy that is theoretically grounded in the knowlege-based theory of the firm. After identifying distinct knowledge groups, the financial performance of the different groups will be compared to either support or reject the concept of equifinality. In a similar manner that Zajac and Shortell (1989) studied strategic change using the Miles and Snow typology, we will also analyze the stability of the knowledge groups. In general, since firms' organizational cultures and knowledge bases evolve through established learning routines (Bierly and Spender, 1995), firms establish momentum and their flexibility in the way they learn becomes limited by a number of organizational rigidities in many different parts of the organization (Bierly and Chakrabarti, 1997; Miller and Friesen, 1984). However, as Zajac and Shortell (1989) illustrated in their study, the conventional widsom that strategies are mostly stable may be overstated. Additional research questions are: Are firms starting in a specific knowledge group or firms changing to a specific knowledge group more able and willing to change than others? Are firms that are more flexible in changing their knowledge strategies more financially successful than firms that are more stable?

METHODS

The present study focussed on the U.S. pharmaceutical industry from 1977 to 1991. We separated the 15-year period into three 5-year periods to see how the clusters changed over time. Aggregate measures for each 5-year period were developed by averaging the measures for each year. This time period was used to ensure a long enough period to smooth out time-related fluctuations. The firms included in the study (a) primarily produce brand ethical drugs (no generic drug producers were included), (b) are U.S. publicly owned companies, and (c) have pharmaceutical sales account for a substantial portion of company sales. Not all firms were included for the full time-frame due to mergers and acquisitions. Only U.S. companies were studied to control for differences across countries (e.g., different accounting methods).

The pharmaceutical industry was chosen for the following reasons. First, the industry is primarily a knowledge-driven industry. Technological learning is a key determinant of the competitiveness of each of the firms in the industry. External factors, such as changes in the economy or exchange rates, do not affect firm profitability as much as the internal capabilities of the individual firm. Second, most of the corporations in the pharmaceutical industry derive the majority of their revenues from the pharmaceutical industry. Thus, most firm characteristics reflect business-level strategic orientations. Third, patent data provide more valid measures in this industry than other industries because of the enforceability of the patents and the lack of secrecy between firms.

Measurements

Financial performance is measured in two ways: return on sales (ROS) and return on assets (ROA), both of which are frequently used measures of financial performance in the strategy literature. The advantages and disadvantages of using ROS and ROA as measures of performance are discussed extensively elsewhere, but it should be noted that both of these financial measures of performance are a narrow conception of performance and do not take into consideration operational (i.e., nonfinancial) measures of performance (Kanter and Brinkerhoff, 1981). The following five independent variables are used to cluster the firms into knowledge groups:

R&D intensity

The R&D intensity (RDS) of a firm is defined as the ratio of annual R&D dollars spent by the firm and the firm's total sales. R&D intensity is used as our primary input variable to internal learning. However, as Cohen and Levinthal (1990) pointed out, a measure of R&D is not only a satisfactory measure of internal learning, but also a prerequisite for effective external learning because firms must develop a certain degree of internal knowledge (absorptive capacity) so that they can understand, interpret, and apply external information.

Science linkage

The level of external learning is measured by the average number of patent citations to the scientific literature, or scientific linkage (SCILINK). Patent citation information provides valuable data concerning the flow of information to a firm from external sources (Griliches, 1990). This is particularly true in the pharmaceutical industry, where technical journals have been cited as the most frequently used source for obtaining new information by research scientists in the industry (Sheen, 1992). The more inventions incorporate recent scientific discoveries from outside the organization and are linked to basic science, the more citations a firm will list on its patents (Narin, Noma, and Perry, 1987).

Knowledge dispersion

The breadth of a firm's knowledge base is measured by using a dispersion index (DISP) that indicates the technological distribution of a company's patents. Specifically, the index is determined by the following equation:

$$\text{DISP} = -1/\ln N \sum_{i=1}^{N} (f_i \times \ln f_i)$$

where f_i = the fraction of patents in ith category. For example, a pharmaceutical company that is granted patents in several therapeutic areas will have a higher dispersion index than a firm focused primarily in one area. A firm with a higher R&D dispersion index is more flexible because (a) it will be better able to shift focus to different therapeutic areas, and (b) it will be able to better combine knowledge in different therapeutic areas (consistent with Kogut and Zander's, 1992, concept of combinative capabilities and Henderson and Cockburn's, 1994, concept of architectural competence).

Technology cycle time

A frequently used measure of learning speed, or technology cycle time (TCT), and a measure that is used in this study, is the median age of the patents cited by a given firm's patents (e.g., Narin, Carpenter, and Woolf, 1984; Bierly and Chakrabarti, 1996). If a firm takes a longer time to incorporate new technologies into its new products or processes, then the average age of its citations will be higher and it will have a higher technology cycle time. On the other hand, if a firm rapidly develops new technologies building on other state-of-the-art technologies, it will have a lower technology cycle time.

Learning radicalness

Whether a firm preferred radical vs. incremental learning (RAD) is measured by the ratio of New Chemical Entities (NCEs) and approved New Drug Applications (NDAs). An NCE is a new product approved by the FDA that consists of an entirely new molecular formula.[1] NDA includes all new drugs that are approved by the FDA, except biologicals and medical devices. This includes all NCEs, new formulations, new combinations, and new indications (or uses). A firm with high learning radicalness is considered to follow a more high-risk knowledge strategy that attempts to hit more 'home runs' and fewer 'singles'.

Statistical analysis and data sources

Cluster analyses, which were used to classify the firms into different groups based on their knowledge strategy, were carried out using the SPSS for Windows (1994) package. Specifically, we

[1] New Chemical Entities, a term used by SCRIPT magazine, is a category similar to, but slightly different than the FDA's New Molecular Entity (NME) category. Specifically, NCEs are equal to the FDA's NMEs minus new biologicals and new medical devices. These two measures are almost identical because there are usually only one or two new biologicals or medical devices approved by the FDA each year.

choose the Ward's hierarchical technique of clustering using squared Euclidean distances. All variables were standardized by using Z-scores so that variables with large units would not be overemphasized. The decision concerning how many clusters to use was guided by the agglomeration schedule, which displays the squared Euclidean distances between each case or group of cases combined to form a cluster for each step of the process. Cluster agglomeration is generally stopped when the increase between two adjacent steps becomes large. We stopped cluster agglomeration with four clusters for each of the 5-year time periods.

Measures of financial performance, R&D expenditures and sales for this study came from company annual reports and their 10-K forms. Patent data were obtained from CHI Research Inc.'s data bases, which, for the years covered in this study, include all patents listed by the U.S. Patent Office. The data base is internationally recognized as one of the most reliable data bases of its type available. The two measures of new products used in this study, NCE and NDA, are primarily from FDA reports and were compared to the other industry sources to ensure the reliability of data.

RESULTS

Before discussing the differences among knowledge groups for each time period, it is important to identify industry changes that are occurring over the same time period. The most general change in the drug industry is the change from a trial-and-error method of drug discovery to a rational drug design approach (Office of Technology Assessment, 1993). In the past, a new drug was typically found by looking for chemicals that caused a particular clinical reaction, a process that did not require the researcher to necessarily understand how the drug worked. A rational drug design approach reverses the process in the sense that by studying the specific disease and having knowledge of how the process works, the researchers design drugs that will serve specific functions. This type of drug design requires more general knowledge about how the processes work and the integration of many different knowledge areas.

This general change within the industry, which is a change in the 'industry recipe' (Spender, 1989), has predictable changes on our data, as displayed by the summary data for each time period in Table 1. Internal and external learning steadily increase throughout our period of study. The average level of R&D intensity increases from 5 percent in Period 1 to 10 percent in Period 3. Likewise, our average measure of science linkage increases from 0.96 in Period 1 to 2.48 in Period 3, which is a clear indication that there is more transfer of knowledge within the scientific community. In addition, technology cycle time and learning radicalness steadily increase during our period of study, indicating that firms are focusing more on radical new drugs and less on 'me-too' drugs.

Existence of different knowledge groups

The cluster analysis identified several distinct generic knowledge strategies among the pharmaceutical firms. Even though some of the firms shifted to different knowledge groups over time, the general characteristics of each of the groups remained stable. Table 1 displays the knowledge strategies for each of the knowledge groups based on our five independent variables for each of the three time periods studied and Table 2 displays each knowledge group membership. The Appendix displays the 'tightness' of each cluster (average squared Euclidean distance) and the 'nearness' of clusters (represented by the maximum squared Euclidean distances). The results of t-test comparisons between the group means of clustering variables found 54 out of a total of 90 group mean differences were significant at the 0.05 confidence level or higher, with each group significantly different than all other groups of the same period. The results of the t-test comparisons strongly support the existence of these different generic knowledge groups. For each of the three time periods, the different knowledge strategies can be summarized as follows.

Knowledge Group 4 can be viewed as the most aggressive learners in the sense that they most effectively combine internal and external learning. These firms have the highest level of internal learning (RDS), are strong in external learning (much higher than the other groups in Periods 2 and 3), focus on both radical and incremental learning, and are one of the fastest learners

Table 1. Variable means for cluster groups and sample for each time period

	RDS	SCILINK	DISP	TCT	RAD
Period I: 1977–81					
KG1—Explorers	0.04	0.78	0.45	6.67	0.18
KG2—Exploiters	0.03	1.39	0.34	6.46	0.08
KG3—Loners	0.06	0.50	0.12	13.28	0.08
KG4—Innovators	0.08	1.22	0.41	5.34	0.34
All groups	0.05	0.96	0.37	7.26	0.19
Period II: 1982–86					
KG1—Explorers	0.09	1.52	0.45	7.72	0.46
KG2—Exploiters	0.06	1.56	0.50	8.61	0.14
KG3—Loners	0.09	0.37	0.15	11.23	0.21
KG4—Innovators	0.12	3.80	0.38	7.29	0.20
All groups	0.08	1.54	0.40	8.82	0.22
Period III: 1987–91					
KG1—Explorers	0.09	2.59	0.50	8.68	0.51
KG2—Exploiters	0.07	1.52	0.53	8.68	0.14
KG3—Loners	0.07	1.03	0.13	11.46	0.00
KG4—Innovators	0.13	3.80	0.41	8.69	0.29
All groups	0.10	2.48	0.42	9.11	0.23

(lowest TCT). Thus, we label this group the '*Innovator*' group, because besides following an aggressive strategy, they appear to have successfully balanced the trade-offs required to be successful, long-term innovators, as outlined in the above discussion.

Knowledge Group 3 can be viewed as mostly ineffective (or isolated) learners in the sense that even though they spend more than the industry average on R&D (except for Period 3), other knowledge indicators point to problem areas. Most importantly, their technology cycle time is much higher than each of the other groups, indicating that they are slow in applying new knowledge, and their science linkage is much lower than all of the others, indicating that these firms remain mostly isolated from the scientific community. In addition, their knowledge dispersion level is very low, indicating they may be too focused in certain areas and not able to integrate different streams of knowledge. We refer to this group as the '*Loners*'.

Knowledge Group 2 can be viewed as the '*Exploiters*'. The firms in this group spend the lowest amount on R&D, have a high level of science linkage, and have a broad (but shallow) knowledge base. Their priority is clearly on external learning more than on internal learning. Not surprisingly, they focus more on incremental learning, probably mostly improvements on competitors' ideas, and less on the development of radically new products. If they do have success with a breakthrough drug, it can be assumed that these companies would spend great effort in maximizing the benefit from the drug by finding new uses for the drug, combining the drug with other established drugs, and have many variations (e.g., different doses) of the drug. Even though marketing expertise was not analyzed as part of this study, one would expect that firms in this group would be excellent marketers to best exploit their line of drugs, which by looking at the firms in this group in Table 2 appears to be the case.

Knowledge Group 1 can be viewed as the '*Explorer*' group. The defining characteristic of this group is their very high levels of radicalness in Periods 2 and 3. They are roughly the same as the industry average in each of the other areas, indicating that they maintain a good balance between internal and external learning, just as the firms in Knowledge Group 4, but they are less aggressive learners than those other firms, as indicated by lower levels of R&D and science linkage for every period. However, their limited resources are spent attempting to 'hit the home-

Table 2. Knowledge group membership

'Explorers' KG1	'Exploiters' KG2	'Loners' KG3	'Innovators' KG4
Period I: 1977–81			
Abbott	American Home Prod.	Carter Wallace	Lilly
American Cyanamid	Bristol Myers	Forest	Merck
Johnson & Johnson	ICN	Marion	SmithKline Beckman
Pfizer	Squibb		Syntex
AH Robins			Upjohn
Rorer			
Schering-Plough			
Sterling			
Warner Lambert			
Period II: 1982–86			
Abbott	American Cyanamid	Carter Wallace	Lilly
Merck	American Home Prod.	Forest	Upjohn
Pfizer	Bristol Myers	ICN	
Syntex	Johnson and Johnson	Marion	
	Rorer		
	Schering-Plough		
	SmithKline		
	Squibb		
	Sterling		
	Warner Lambert		
Period III: 1987–91			
Abbott	American Cyanamid	Carter Wallace	Lilly
Pfizer	American Home Prod.	Forest	Merck
	Johnson & Johnson		Schering-Plough
	Warner Lambert		Syntex
			Upjohn

run' with a new blockbuster drug. As the Appendix indicates, Knowledge Groups 1 and 2 are the most similar for each of the three time periods, and Knowledge Groups 3 and 4 are the most dissimilar.

Profit differentials of knowledge groups

Table 3 displays the mean profit margins (ROS and ROA) for each cluster group for each time period. In general, the Innovator and Explorer knowledge groups maintained higher profit margins throughout the period of study and the Loner and Exploiter knowledge groups maintained lower profit margins. The results of *t*-test comparisons between group means found the following statistically significant differences at the 0.05 confidence level or higher: for Period 1, the Innovator group had significantly higher performance by at least one measure than all of the other three groups; for Period 2, the Explorer group had significantly higher performance by at least one measure than the Exploiter and Loner groups; for Period 3, the Innovator group had significantly higher ROS than the Exploiter group. These results, though they are not conclusive, tend to support the assertion that, in the pharmaceutical industry, firms that have a more aggressive knowledge strategy have higher financial performance. This finding emphasizes that, for this industry, a key success factor is the development of new blockbluster drugs, more so than the incremental improvements to current products.

Stability of knowledge groups

The analysis of the stability of the knowledge groups is difficult because there are several major industry changes, as noted above. Thus, unless a firm increases internal learning (R&D) and exter-

Table 3. Group financial performance means for cluster groups and sample for each time period

	ROS	ROA
Period I: 1977–81		
KG1—Explorers	0.09	0.09
KG2—Exploiters	0.06	0.08
KG3—Loners	0.06	0.06
KG4—Innovators	0.14	0.13
All groups	0.09	0.10
Period II: 1982–86		
KG1—Explorers	0.14	0.13
KG2—Exploiters	0.10	0.10
KG3—Loners	0.08	0.07
KG4—Innovators	0.12	0.10
All groups	0.10	0.10
Period III: 1987–91		
KG1—Explorers	0.14	0.13
KG2—Exploiters	0.11	0.13
KG3—Loners	0.15	0.10
KG4—Innovators	0.19	0.16
All groups	0.15	0.14

nal learning (SCILINK) at a rate of at least as much as the industry average, its learning, relative to its competitors, will be decreasing. Thus, the critical characteristics of the knowledge groups changed over time as each of the groups evolved. Despite these changes, which make it difficult to have comparable knowledge groups in the different time periods, most of the firms remain in the same knowledge group over time. Specifically, 10 of the 20 firms in Period 2 were in the same knowledge group in Period 1 and 10 of the 13 firms in Period 3 were in the same group in Period 2. As expected, most of the movement to different groups is when a firm moves to another knowledge group that is 'close' to it (see the Appendix for squared Euclidean distances). For example, six of the 10 firms that moved between Periods 1 and 2 moved from the Explorer knowledge group to the Exploiter knowledge group, which are two groups that are 'close' together. This seems to indicate that during this time period these six firms shifted their primary focus from developing radical new drugs to maximizing their return by incrementally improving existing products. However, having this many firms move from one group to another may also be an indicator that the firms were clustered differently for the different time periods.

Despite the above precautions, looking at the stability and shift of firms' knowledge strategy is informative. Table 4 illustrates the strategically stable firms within each knowledge area and the firms that have changed their knowledge strategies. In addition, Table 4 displays the average adjusted ROS (AROS) for each group, which is defined as the return on sales above or below the industry average for the given time period. Even though this further segementation has left us with groups with too low a number of firms in each group to analyze formally, several broad trends appear evident. First, firms that remain strategically stable throughout the study appear to be more profitable than firms that change their strategy, with the exception of the group that changes its strategy to become more aggressive learners. This group that has changed its knowledge strategy toward the Innovator category has the highest profit margin of all groups, even higher than the firms that have remained in the Innovator category throughout the study. Second, a large group of firms shifted their strategy from either the Innovator or Explorer group to the Exploiter group. On average, these firms had below average profit margins. Each of these firms have shifted from being one of the more aggressive learning organizations in the industry to a follower. These firms are no longer primarily seeking to create radically new ideas, but instead focus their resources on exploiting their past successes. Third, none of the firms in the Loner group changed their strategy to shift to another more profitable group. Only one firm changed its strategy to become a Loner, and its performance was very poor.

CONCLUSION

The purpose of this study was to initiate exploratory research in the area of knowledge strategies. By extending the knowledge-based theory of the firm and the literature on organizational learning, we outlined the core strategic decisions that comprise a firm's knowledge strategy. Focusing on one industry, the U.S. pharmaceutical industry, we quantitatively determined the existence of several different generic strategies in the way firms acquire and generate knowledge, which, for most firms, are stable over a long time period. We labeled these generic knowledge strategies: Inno-

Table 4. Knowledge group membership

Strategically stable groups				
	1977–81	1982–86	1987–91	Average AROS[a]
KG1 'Explorers'	Abbott Pfizer	Abbott Pfizer	Abbott Pfizer	0.013
KG2 'Exploiters'	AHP Bristol Myers Squibb	AHP Bristol Myers Squibb	AHP	0.016
KG3 'Loners'	Carter Wallace Forest Marion	Carter Wallace Forest Marion	Carter Wallace Forest	−0.004
KG4 'Innovators'	Lilly Upjohn	Lilly Upjohn	Lilly Upjohn	0.032

Strategic changes of groups			
Strategic change	Change path	Change path	Average AROS[a]
To 'Exploiter'	KG1 → KG2 → KG2 American Cyanamid Johnson & Johnson Warner Lambert Rorer Sterling	KG4 → KG2 SmithKline	−0.014
To 'Innovator'	KG1 → KG2 → KG4 Schering Plough	KG4 → KG1 → KG4 Merck Syntex	0.055
To 'Loner'	KG2 → KG3 ICN	–	−0.115

[a]Adjusted return on sales (AROS) is defined as the firm ROS minus the industry average ROS for that time period.

vators, Explorers, Exploiters, and Loners. Our study indicated that in the pharmaceutical industry certain strategies (Innovators and Explorers) are linked to higher profits, and other strategies (Loners and Exploiters) are linked to lower profits. However, the study also indicates that the firms in the less profitable knowledge groups either do not desire or are unable to change their strategies. Most likely, the explanation for this behavior is either that these firms' learning routines have become so ingrained that they have become rigidities and the firms can not change the way they learn, or that these firms lack the resources and capabilities to follow one of the other knowledge strategies.

Of course, the generalizability of these preliminary findings to other industries must be made cautiously until further research of other industries is completed. Logically, our results are most applicable to other knowledge-based industries in dynamic and complex environments (hypercompetitive conditions). We believe the four generic knowledge strategies derived in this study (Innovators, Explorers, Exploiters, Loners) exist in other industries. Examples of firms that follow each strategy readily come to mind: Intel, 3M, Chaparral Steel and Wal-Mart are Innovators; Compaq, Toyota, Honda and many other Japanese firms are Exploiters; Netscape Communications, Ben and Jerry's, and many biotechnology companies are Explorers; Cray Computer Systems, Caterpillar, Kodak and Digital are Loners. There are certainly other possible configurations of our four basic strategic choices concerning knowledge management, but the four combinations which make up these generic knowledge strategies appear to display internal consistency. Each set of decisions appears to mutually reinforce a consistent organizational culture and provide fundamentally different approaches to managing internal and external learning. However, Henderson (1994) has described how in many respects the pharmaceutical industry is exceptional concerning how well the firms learn in a dynamic environment. Unlike many other large companies, they have avoided competency traps and have institutionalized a 'deeper' approach to learning. This is partially due to the unique industry structure and reward system influenced by the drug approval process, the health care system, and the patent system. Thus, firms in this industry may have more clearly defined knowledge strategies than firms in other industries, where some firms may have more haphazard strategies and some firms may follow no strategy at all.

On the other hand, we do not believe the same generic knowledge strategies of the firms in our study that are most highly associated with financial performance will also be the most successful in other industries. For each of our generic knowledge strategies there are examples of firms in other industries that have been successful, and firms that have been unsuccessful. More than one generic strategy may be successful in an industry. Industry characteristics such as the rate of change, the nature of the key technologies, the importance of economies of scale and scope, and the degree of competition will influence the appropriability of profits from an innovation. Also, in some industries the risk associated with failure may be very high, suggesting a more conservative knowledge strategy may be appropriate. Thus, whereas the generic strategies exist in other industries, the characteristics of the industry will determine which strategies are successful.

We believe the development of a dynamic knowledge strategy typology or taxonomy will offer more insight than the basic static strategy typologies developed to date. Other generic strategy typologies, such as Porter's (1980), rely on basic assumptions that are not valid for many industries today. Specifically, they assume that (a) the primary focus of strategy is about the positioning of an end-product within an identifiable industry structure and (b) the industry structure is relatively stable and changes to the environment are mostly incremental, linear changes that do *not* redefine the product or industry. However, other researchers have observed the preponderance of boundaryless industry structures, hypercompetition, increasing globalization, an increasing rate of technological change and diffusion, and a tremendous increase in access to information through the advances in computers and communications (Bettis and Hitt, 1995; D'Aveni, 1994; Hamel and Prahalad, 1994). The 'static' generic strategy typologies offer little practical value to top managers in determining how to *develop* a competitive advantage, which is the primary purpose of strategy. Alternatively, a knowledge strategy typology can provide a guide to action for managers and assist them in learning and building their core competencies into sustainable competitive advantages. It can be applied in a turbulent environment, is not constrained to business-unit level of analysis, and can provide guidance for action for firms competing in several related industries, including new emerging arenas. In addition, a generic knowledge strategy typology or taxonomy based on the knowledge-based theory of the firm will have a sound theoretical base, which has not necessarily been the case for other generic strategy typologies.

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APPENDIX: INTERDIFFERENCE MATRICES FROM CLUSTER ANALYSIS[1]

Period I: 1977–81

	Explorers KG1	Exploiters KG2	Loners KG3	Innovators KG4
KG1-Explorers	2.3362	17.6635	25.0433	24.2713
KG2-Exploiters		4.6677	29.3569	28.1834
KG3-Loners			10.7503	41.6089
KG4-Innovators				5.0046

Period II: 1982–86

	KG1	KG2	KG3	KG4
KG1-Explorers	4.2392	13.9912	23.0740	15.5247
KG2-Exploiters		3.2192	31.1157	16.2437
KG3-Loners			11.1423	31.8465
KG4-Innovators				0.5592

Period III: 1987–91

	KG1	KG2	KG3	KG4
KG1-Explorers	3.4398	11.5958	19.8353	15.6317
KG2-Exploiters		1.8544	15.6620	16.4339
KG3-Loners			2.8264	26.2324
KG4-Innovators				4.7507

[1]The 'tightness' of a cluster (underlined diagonal) is represented by its average squared Euclidean distance. The 'nearness' of clusters is represented by the maximum squared Euclidean distances.