ATTAINING TECHNOLOGICAL SYNERGIES IN DIVERSIFIED FIRMS

Robert K. Kazanjian and Praveen Nayyar

INTRODUCTION

Selznick (1957) was the first to recognize the importance of distinctive competence for competitive strategy. A distinctive competence represents those activities which firms, or their subdivisions, perform better relative to their competition. Distinctive competencies may be related to a firm's primary markets or technologies and firms may seek to exploit such competencies when they diversify (Ansoff, 1965).

Typically, the exploitation of such distinctive competencies across multiple businesses results in what has been termed related diversification (Rumelt, 1974; Wrigley, 1970). The economic justification of related diversification strategies rests on the premise that economies of scope (Panzar & Willig, 1982; Teece, 1980), or synergies, result in decreased costs for related businesses in diversified firms compared to the costs that are incurred by independent businesses producing the same outputs.
Such economies may arise due to inputs which are shared without congestion (Willig, 1979). Increasing returns to scale (or indivisibilities) in any factor, imperfect markets for the factor and the absence of further markets for any one product produced from the factor are necessary conditions for the existence of economies of scope (Rumelt, 1982). Potential economies of scope constitute an incentive for a firm to diversify since there exist opportunities to use resources more profitably than they are currently being used.

While synergy has often been postulated as a motive for diversification, it should be noted, however, that the potential for synergy does not automatically imply that synergy will actually be realized. The realization of synergy "depends on the manner in which the new acquisition (new business) is integrated into the parent organization" (Ansoff, 1965, p. 82). The decision to diversify implies that the firm has to consider how the potential synergies will be realized. Ansoff suggested that "the choice of the synergy-structure relationship ... is a key management decision which affects the final product—market strategy of the firm" (1965, p. 167).

Reed and Luffman wrote that the "benefits of synergy are truly legendary. Diversification and synergy have become virtually inseparable in texts and business language. Yet, those particular benefits show an almost unshakable resolve not to appear when it becomes time for their release. To realize even a part of the potential requires substantial effort on the part of the diversifying firm because the prizes are far from automatic. Stories of success invariably contain details of the great efforts needed to capitalize upon the potential benefits" (1986, p. 34).

Firms must pay attention to not only the potential for synergy, but also to the ways in which that potential will be realized, the likelihood of its realization and the organization designs needed to maximize the realization of potential synergy at minimum organizational cost. Barriers to the realization of potential synergies and organization designs adopted to overcome them may, however, vary with different types of relatedness. This is because divisionalized technology intensive companies are finding it increasingly urgent to surmount their divisions' reluctance to share technological advances so as to benefit from interdivisional sharing (Adler, 1989).

Corporate level organization and staffing patterns to support different diversification strategies have been documented (Galbraith & Kazanjian, 1986; Pitts, 1977) and several researchers have cautioned that the benefits of synergy are not automatic, that firms have to devise ways to capture these potential benefits, and that firms are not always successful in doing so. Few suggestions on how firms should go about capturing the potential synergies promised by different types of relatedness have been offered. Such inquiries, by definition, center on functional level resources and activities (Kazanjian & Drazin, 1987).

This paper focuses on the specific actions that diversified firms may take to realize the potential benefits offered by technological synergy among their
businesses. In the next section we develop a classification scheme for technologies to ascertain the extent of difficulty likely to be associated with attempts to realize potential technological synergies across businesses. We then examine organizational barriers to the attainment of technological synergy and explore ways to overcome them based on the nature of the technological interdependence among organizational units in diversified firms. This leads to a discussion of a preliminary field study of actions and approaches which firms have instituted to attain technological synergies. Finally, based on the classification scheme and the nature of technological interdependence among organizational units explored to that point, we develop some propositions about the types of mechanisms that firms may appropriately adopt to capture technological synergies.

A CLASSIFICATION SCHEME FOR TECHNOLOGIES

Technology is a form of knowledge and like all forms of knowledge it is generally intangible (Winter, 1987). It resides in plant and equipment in the form of process technology and in products in the form of product technology. In addition, technology possesses characteristics of a public good—it can be used without diminishing its stock, thereby exhibiting economies of scale. Further, the transfer of technology across markets is fraught with hazards since its intangible nature impedes market exchange due to the presence of moral hazard and adverse selection problems (Stigler, 1961). Hence, if a firm is unable to fully exploit the technologies it possesses in any one business and that technology can be used in other businesses, the firm would obtain significant synergistic advantages if it could devise ways to share or transfer technology across businesses.

Not all technologies are alike, however. Winter (1987) suggests a number of taxonomic dimensions of knowledge, two of which we feel can be fruitfully applied to differentiate among different types of technologies with respect to the difficulties associated with their transfer within the firm.

Technology may be tacit or articulable. Tacit technology is one that its user or possessor may not be able to fully describe. Individual skills are often of this type. They are often applied by following a set of rules, but those rules are not known as such to the persons observing them. Firms may possess tacit technology in the form of individuals with skills based on tacit knowledge or the firm may use certain routines and repertoires or have in place relationships that are thoroughly embedded in the social structure of a unit and the interaction patterns of its members. As such, these technologies are not completely understood by its members individually. Many design techniques and complex manufacturing processes used in firms are forms of tacit technologies. In contrast, articulable technologies are those that freely and
easily can be communicated among persons and are heavily embodied in the
plant and equipment required, such that all interested persons can become
equally knowledgeable about them. Many manufacturing technologies
associated with mature commodity businesses are articulable. This dimension
is similar to Perrow's (1967) notion of task analyzability.

Firms use a variety of technologies, some of which may be tacit and some
may be articulable. The former will present far greater difficulty in sharing
or transferring between or across business units as compared to the latter
because of the inability of the possessor of the technology to articulate it.
Though a technology may be tacit, it may be teachable through observation
and trial and error. Sharing or transferring tacit technologies would require
information of a greater richness (Daft & Lengel, 1986) than technologies that
are articulable. The greater the richness of information required, the greater
will be the efforts expended to generate that information.

A second dimension of technology offered by Winter (1987) is whether it
is relatively simple or complex. A simple technology may be adequately
described by relatively little information while a complex technology requires
a relatively large amount of information to fully describe it. For example, the
technology of internal combustion engines is relatively simple when compared
to the technology used in nuclear power plants. Firms use technologies that
may lie anywhere on the continuum from simple to complex. Simple
technologies will be relatively easy to share or transfer when compared with
relatively complex ones since the amount of information that will have to be
conveyed by the possessor of the technology and assimilated by the receiver
in the former case will be much smaller.

Although other dimensions or characteristics of technology have been
identified and discussed, most notably task variety and task analyzability
(Perrow, 1967) and maturity or stage of development (Meyer & Roberts,
1986), these two dimensions of technology, simple-complex and tact-articulable,
may be combined into the matrix in Figure 1 to yield a useful
classification scheme that helps determine the extent of difficulty associated
with attempts to attain technological synergies. We will argue that the extent
development in attaining effective technology transfer and hence synergy, will
be a function of the amount and richness of the information required to share
or transfer any specific technology. We will also argue that the specific
organizational arrangements that will facilitate sharing or transferring
technology across businesses are likely to vary with the nature of the
technology involved as determined by the quadrant of Figure 1 in which the
technology lies.

According to this logic then, those technologies which are simple and
articulable are the easiest to transfer and therefore hold the highest prospect
for creating synergy, while those which are complex and tacit are the most
difficult to transfer and require considerably more effort to realize synergistic
<table>
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<th>TACIT</th>
<th>ARTICULABLE</th>
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<tr>
<td>COMPLEX</td>
<td>Most difficult to transfer.</td>
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<tr>
<td></td>
<td>Could provide sustainable</td>
</tr>
<tr>
<td></td>
<td>competitive advantage.</td>
</tr>
<tr>
<td>SIMPLE</td>
<td>Moderately difficult to transfer.</td>
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<td></td>
<td>Least difficult to transfer.</td>
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<td>Unlikely to provide</td>
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<td>sustainable competitive</td>
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*Figure 1.*

...effects. Technologies which are simple and tacit, or complex and articulable present moderate challenges to transfer and synergy attainment.

It should be emphasized that not all technologies are equal in strategic importance. It is probably the case that those technologies which are simple and articulable are not only more readily transferred and shared across business units within the firm, but are also more easily subject to analysis and imitation by competitors (Barney, 1986). Of course, the reverse would be expected for technologies which are complex and tacit. These latter type of technologies would be characterized by what Lippman and Rumelt (1982) termed "uncertain imitability." Therefore, attaining technological synergy is a function of maximizing both the transfer of those specific technologies which provide the highest prospect for sustained competitive advantage as well as the sheer number of common technologies which could be shared, thus providing greater efficiency benefits.
ORGANIZATIONAL BARRIERS TO ATTAINING
TECHNOLOGICAL SYNERGIES

In addition to difficulties in realizing the benefits of technological synergies that arise due to the inherent characteristics of the technologies involved as discussed above, there are a number of organizational barriers to the successful realization of technological synergies (Adler, 1989; Gartner & Naiman, 1976). The existence of organizational barriers implies that firms must design organizational mechanisms to overcome them if they are to realize the potential benefits of technological relatedness.

Relatedness implies the existence of interdependencies among the organizational units that are related. Interdependencies lead to difficulties in resource allocation and an increased need for coordination across the affected organizational units (Riordan & Williamson, 1985). While firms may install managerial control and incentive systems that are designed to attenuate such problems by providing “market-like” incentives to managers, incentive degradation and bureaucratic distortions effectively limit their usefulness (Riordan & Williamson, 1985).

Technology, or resource, sharing between organizational units in diversified firms implies that managers need to simultaneously manage both diversity and vertical integration. Managers of the two or more units that share resources must both cooperate with respect to the shared resources, and compete with respect to their “home” business priorities. In addition, vertical integration and diversification require different organizational arrangements. Firms then need to bridge these differences as well as foster cooperation on technological initiatives among business units which simultaneously are competing for other resources.

There are a number of barriers to the realization of technological synergy. Some of these have been discussed within the technology transfer literature (Gartner & Naiman, 1976; Gruber & Marquis, 1969; Souder, 1986; Tornatzky et al., 1983). These have typically included factors such as inadequate resources and competencies (staffing and training), behavioral influences (such as the not-invented-here syndrome), geographical and structural barriers, lack of positive rewards, and the lack of strong advocates in the technology developing and using organizations. It should be noted, however, that most of this work centers on technology transfer problems between the developers and the users of technology within the same business unit. Little, if any, work addresses the unique barriers that might be associated with transferring and sharing technology across two or more business units. We assume, nonetheless, that many of the same organizational barriers would hold in the latter setting.

An additional barrier may arise due to the absence of a clear and explicit strategy which indicates the intention to target, transfer and utilize knowledge across organizational units. Management may well intend such transfers, but
may also assume that they are naturally occurring (Nayyar, 1988). However, barriers to the attainment of technological synergies, whether arising from the characteristics of technologies or from organizational sources, dictate that firms need to devise and install appropriate organizational mechanisms that will overcome them.

Research Approach

As little research has been conducted on how firms actually attain synergy, a small sample field study was conducted to allow for exploratory discussion and development. As relatedness was a prerequisite, Rumelt (1974) and Bettis and Hall (1982) were used as a guide to identify candidate firms. Additionally, as the objective was to identify factors that might lead to successful joint use of technology, firms included had to be high (above average) performers as measured by average return on equity from 1983 to 1985. Of an initial list of 22 such firms from the above referenced studies, 6 were included based on identification of respondent, role and importance of technology, and willingness to participate.

Data was collected through telephone interviews with the senior technical manager of the firm. Respondents were senior corporate level executives in research and development, and technology planning. Interviews were structured, but provided for open ended questions which allowed respondents to describe the practices of their firm. Questions were directed at determining specific actions taken by firms to facilitate the sharing of common technologies as well as the maximum utilization of technological resources. Additional information was collected regarding the business portfolio and the character of relatedness of that portfolio.

MECHANISMS FOR ATTAINING SYNERGIES: RESULTS OF A FIELD STUDY

The field interviews resulted in the identification of a series of mechanisms employed by the firms studied to attain technological transfers and synergies. Each is discussed in detail below.

Written documents, reports, and research findings: Each firm engages in the systematic collection, organization and storage of information on their technological development activities. This documentation can then be published and disseminated to business units which might have an interest or need for that technology. This seems to be the simplest and most prevalent form of technology transfer employed.
Resource allocation to identified discrete or core technologies: Most firms indicated that they engaged in specific and detailed technological forecasting and planning. This typically entailed identifying the specific technologies which the firm has adopted, developed or planned to develop, and then allocating resources across those technologies consistent with the strategies of the businesses. Such portfolio practices allow firms to focus and leverage their technological resources, while creating the capability to engage in some of the mechanisms which are discussed below.

Formation of internal technological networks: Once discrete technologies have been identified, several firms then developed directories or listings of scientists and engineers who were interested in or actively pursuing these areas. It was then possible for these individuals to contact each other on a spontaneous basis; thus creating informal networks around individuals or groups of technologies within the firm.

Organization of internal symposia: Several firms went beyond the reinforcement of informal networks by organizing internal symposia or conferences where technological professionals from different business units would gather to present their recent work in their area. These covered the range from basic to more applied research orientations.

Job rotation and personnel transfers: As has been argued in much of the innovation literature, an effective mechanism to transfer know-how is to transfer people. Here, firms indicated that both bench-level scientists and engineers, as well as managers within the technical organizations, were regularly rotated across business units to either transfer a specific technology or to keep channels of communication across groups open.

Liaison roles: Several firms designated technical liaisons as formal contact points. A common application of this is to have a liaison between the corporate R&D laboratory and specific business units. Such roles again increase communication and hence the prospect that applicable technical knowledge will be identified early and employed efficiently. Such roles also help in identifying common needs across businesses which might result in the new developmental projects.

Ad hoc teams: At least one firm maintained that it regularly created technical teams drawn from different parts of the company to solve particular technologically related problems. This allowed the firm to realize the maximum capabilities of the firm. Once the problem was solved, the team was disbanded.
Use of recognition, incentives, and specific objectives: At least one firm consciously works at creating a culture and reward system which reinforces technical excellence, broadly defined to include development, transfer, and application of new technologies across business unit lines. Additionally, another firm provides bonuses based upon the percentage of products developed within the most recent five year period. These incentives and objectives, when linked with the knowledge of the technological output of other business units, increases the likelihood that executives will search out pertinent technologies from across the firm.

Utilization of joint R&D efforts: Probably the clearest example of economies of scope related to technology in the diversified firm is the use of a central R&D laboratory, where developmental activity and the associated physical assets applicable to multiple businesses can be pooled and the results shared across businesses. However, this drive for economies of scope was also found in firms where a sub-set of the firms’ business units which relied on common technologies, shared a research facility, or where as few as two business units within the firm conducted joint research projects.

Internal capital market: Several firms view the process of obtaining funding for a new technology to be a critical determinant of success in the development of new technology. Since technology emanating from within the firm will most likely be related to existing technology, it, by definition, is likely to be applicable across at least a subset of units of a related diversified firm. Consequently, these firms engage in a practice of allowing proponents of developmental projects for new technologies to solicit funding from any business of the company. This creates a free flow of ideas (as well as capital), which also makes managers in different businesses aware of technological developments in other areas of the firm.

Position of chief scientist or chief technical officer: Several firms have identified a new position of chief scientist or chief technical officers as a mechanism to oversee the technological strategy of the firm. This individual is usually the coordinator of the technology planning activity of the firm and may also be responsible for the central R&D laboratories.

Technology managers: One of the firms in the sample created a role of technology manager. This position would be staffed by an individual who is active in a particular technology area and who would be made the coordinator for that technology across the firm. In addition, such persons would be knowledgeable about developmental activity across the firm, be responsible for advocating that technology in the resource allocation process, scanning the technical community for new technological developments of concern, and then
would facilitate transfer of know-how across users of the technology in different businesses.

**Grouping of businesses with related technologies:** Several firms were large and diverse enough to allow them to create groups or sectors around business units with highly related technologies. The business units within these entities then had a common reporting structure as well as some shared R&D facilities. Having a group or sector executive was seen by some firms as creating a "forcing function" for the realization of technological synergies.

**Internal technology markets:** Several firms have allowed managers of individual businesses to subcontract for technology development from technical groups in other parts of the firm. This practice allows for the free flow of technology across businesses and capitalizes on maximizing the utilization of existing competencies.

**Problem solving or technology review sessions:** Somewhat similar to the informal, ad hoc committees discussed above, this approach allows for technical competencies in one business to be applied to technical problems in another. One firm, in particular, employed this approach regularly to undertake product and process design reviews.

**The technology of technology transfer:** Increasingly, the work of technology development and transfer is becoming itself technology dependent. With the advent of computer aided design and computer aided manufacturing (CAD/CAM), and the development of sophisticated, voice and data telecommunication networks tailored to individual firms, consistency of approach within the firm becomes a factor in realizing synergy. Compatibility of hardware and software, as well as a consistency in design and documentation standards or database configuration across business units becomes an important, if not a limiting, factor.

A review of these findings suggests that the many of these mechanisms are organization design variables which facilitate lateral relations and increase the firm's information processing capacity (Galbraith, 1973). More specifically, they are directed at transferring technical know how and related information from one business unit to another within the firm. They can be seen as a focused effort to overcome the impediments to synergy discussed earlier. It is interesting to note that most of these efforts such as the creation of technical networks, sponsoring of internal symposia, and job rotation are directed at increasing the general flow of technological knowledge across units. Others of these, however, such as ad hoc teams, problem solving and technology review sessions, or targeted joint research, seem linked to specific technologies and projects.
Alternatively, these mechanisms suggest a rather clear grouping into five independent categories. First, with a single mechanism is the category of shared resources. This is the most direct form of synergy attainment, and it would include reliance on joint R&D. A second category would be standard task systems and practices, which would include the use of written documents, reports, and research findings, as well as an emphasis on compatibility of the technology. The third category includes those mechanisms which could be considered formal organizational structure or lateral relations mechanisms. This includes formal positions such as chief technical officer, technology managers, or the structural configuration of business units, as well as liaison roles and ad hoc teams. Fourth would be those mechanisms which could be considered part of the planning, funding, and review practices of the firm, such as resource allocation to discrete technologies, internal technology markets, internal capital markets, or the regular use of cross business unit problem-solving or technology review sessions. Finally, there is a category which emphasizes human resource practices and the facilitation of face-to-face interactions. This includes the creation of informal technology networks, the sponsoring of internal symposia, job rotation and personnel transfers, as well as the use of recognition, incentives, and specific objectives. These categories and the mechanisms associated with each are presented in Table 1.

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<tr>
<th>Table 1.</th>
<th>Mechanisms for Attaining Synergies</th>
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<tr>
<td><strong>Shared Resources</strong></td>
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<td>• Utilization of joint R&amp;D efforts</td>
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<td><strong>Standard Task Systems and Practices</strong></td>
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<tr>
<td>• Use of written documents, experts, and research findings</td>
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<tr>
<td><strong>Formal Organizational Structure</strong></td>
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<td>• Liaison roles</td>
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<td>• Ad Hoc teams</td>
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<td>• Problem-solving or technology review sessions</td>
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<td><strong>Human Resource Practices</strong></td>
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<td>• Formation of internal technological networks</td>
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Theory

We subscribe to an information processing perspective of organization design (Galbraith, 1973). According to this view, organizations are configured to facilitate the flow and processing of information. Information requirements are largely a function of the primary tasks of the firm, typically reflecting the degree of uncertainty and diversity of the tasks, as well as the interdependence among units associated with those tasks (Galbraith, 1973). Although a number of other variables or task characteristics have been examined as contingency factors in the organization design literature, uncertainty and interdependence are particularly well suited to the discussion of technology transfer and synergy.

The tasks of developing and sharing an individual technology may reflect high degrees of uncertainty and interdependence, depending upon the character of the technology. Obviously, the more the number of discrete technologies to be shared, the higher the task diversity. Technology development is the development of new knowledge or the application of existing knowledge in a new way. This is an inherently uncertain process. Such uncertainty typically revolves around how to make the technology work, and how long it will take to do so. Clearly, if the technology is to be shared, multiple units must be involved, defining a greater level of interdependence.

As Daft and Lengel (1986) note, different modes of communication vary in their capacity to process rich information:

Information richness is defined as the ability of information to change understanding within a time interval. Communication transactions that can overcome different frames of reference or clarify ambiguous issues to change understanding in a timely manner are considered rich. Communications that require a long time to enable understanding or that cannot overcome different perspectives are lower in richness. In a sense, richness pertains to the learning capacity of a communication (p. 560).

Daft and Lengel (1986) then define a number of media, each appropriate to deal with a varying degree of richness. These range from face-to-face communications which provides the richest communications, given the opportunities for immediate feedback and the ability to read language, voice and body language cues, to numeric documents, which provide no such clues and hence offer the least capacity to process rich data.

This argument suggests that, first task contingencies must be assessed to determine not only the quantity of information which the organization must be designed to process, but also the quality and character of that information. We would propose then, that the specific synergy attainment mechanisms employed must reflect the characteristics of the technologies involved with respect to the amount and nature of information that needs to be processed among business units to attain technologic synergies.
In reviewing the categories of synergy attainment, it appears that some categories provide a greater facility for processing rich information than do others. In particular, standard task systems and practices provide the least such facility as they rely primarily on written documents and the formal exchange of information. Human resource practices and formal organization structures probably provide the greatest ability to process rich information, as they emphasize and manifest face-to-face interactions. The category of planning, funding, and review practices provide moderate levels of ability to process rich information.

Before developing specific propositions, it is important to note two assumptions. First, the firm must be concerned with economy in its selection of such mechanisms. Adopting additional mechanisms when they are not required adds administrative costs and as a result might offset any synergistic gains. Therefore, the firm should adopt as few of these mechanisms as are required.

Second, we assume that two categories of these mechanisms, shared resources and standard task systems and practices, are highly desirable in any context, as they provide a necessary and immediate level of synergy independent of the character of the technology in question.

As indicated in Figure 1, technologies which are tacit and complex are the most difficult to share and transfer. They require high volumes of very rich information (typically to and from multiple parties), so that those business units which did not develop or currently do not use them, but can benefit from them, will be able to understand, learn, and adopt them in a timely fashion. Such technologies, therefore, will require the use of many, if not all categories of synergy attainment mechanisms, as multiple channels of communication will be required which allow for considerable iteration and elaboration of communication, much of it face-to-face. Most critical, however, will be human resource practices and formal organizational structures which emphasize rich information processing capacity.

Accordingly, those technologies which are simple and articulate face fewer barriers to synergy, thus presenting the least difficulty in sharing and transfer across business units. This would require relatively lower levels of information which are less rich. As a result these technologies may require far fewer mechanisms beyond shared resources and standard task systems and practices.

Technologies that are complex and articulate, or simple and tacit, require either less information which is very rich, or high amounts of rather standard, easily interpreted information. Such a moderate amount of information processing capacity in both volume and richness, therefore, would require a mix of mechanisms from all categories, but no more than a few from each.

This argument, summarized by Figure 2, can be captured in the following propositions:
Proposition 1. The greater the complexity and tacitness of a technology, the greater the amount and richness of information required to share and transfer that technology. This requires use of multiple mechanisms for synergy attainment within all categories.

Proposition 2. The greater the complexity and tacitness of a technology, the greater the need for human resource practices and formal organizational structure mechanisms to attain synergistic effects.

NEXT STEPS FOR RESEARCH

The preliminary findings of practices pursued by successful technologically related diversified firms present grounded data descriptive of how firms might attain technological synergy. This then provides a basis for developing some preliminary models addressing several interesting research questions which might be empirically investigated. One is to what extent firms actually pursue

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<td>COMPLEX</td>
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<tr>
<td>- Heavily reliant on all Mechanisms.</td>
<td>- Require a moderate mix of mechanisms from all categories.</td>
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<td>- Emphasizes human resource practices and formal organizational structures.</td>
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<tr>
<td>SIMPLE</td>
<td></td>
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<tr>
<td>- Requires a moderate mix from all categories.</td>
<td>- Relies primarily on shared resources and standard task systems and practices.</td>
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<td>- Requires a minimum of formal organizational structural as well as planning, funding and review practices.</td>
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*Figure 2.* Type of Technology and Mechanisms for Attaining Technological Synergy
technological synergy. Given this listing of mechanisms directed at synergy, it would be possible to conduct a large sample survey based study to assess the prevalence of such strategies. Such a study might represent one of the few investigations of whether or not firms do actually pursue synergy.

Probably the most interesting questions are those regarding the propositions developed above and linked to the performance of the firm. We expect that firms that employ such practices in appropriate contexts would be higher performers as determined by accounting based, strategic, or other measures of performance. This would also provide a rough test of the effects of joint benefits versus the administrative costs of such practices.

In summary, this study has undertaken a preliminary and simple inquiry into the mechanisms by which technologically related diversified firms attain synergies. A set of practices has been identified and possible follow-on research questions proposed.

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