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EVALUATING TECHNOLOGICAL COLLABORATIVE OPPORTUNITIES: A COGNITIVE MODELING PERSPECTIVE

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Academic scholars, practitioners, and the public press have reported a number of factors believed to be relevant to decisions regarding technological collaboration. However, little is known about how executives actually weigh and integrate the available information during the evaluation process. This exploratory study uses policy capturing to examine managerial and economic information top executives consider when evaluating scenarios representative of cooperative technology development opportunities. Top executives are found to incorporate information associated with several prominent theories in the strategy literature (e.g., normative strategy, transaction cost economics, options theory). Executive cognitive limitations were also found to influence the evaluations. The study's results suggest a preliminary integrated behavioral model of the factors managers use in assessments of technological collaborative opportunities. Implications for research and practice are set forth.

Technology-driven companies in the 1990s must address an ever-changing competitive landscape. The rising cost of development, rapid technological diffusion, compression of product life cycles, product and market uncertainties, and globalization of competition are affecting the competitive balance. In this time of turbulence and uncertainty, many firms are finding collaborative relationships an advantageous method of technological development (Pennings and Harianto, 1992; Williamson, 1991). This wave of technological cooperation is not only a result of the current competitive environment, but it is also actively shaping the competitive arena in many industries (e.g., pharmaceuticals and telecommunications). Shrewd industry participants recognize that collaboration is competition in a different form and never forget that their partners may be out to disarm them (Hamel, Doz, and Prahalad, 1989). Less discerning executives often find that they entered cooperative relationships without clear strategic objectives or an understanding of how their partner's objectives could affect their future competitiveness (e.g. Hamilton, 1986; Reich and Mankin, 1986; Tanzer, 1992).

Although reports of proposed or established technological collaborations are mentioned daily by the public press, very little is known regarding the process executives use to evaluate potential collaborative opportunities. Glimpses of the types of information that are believed to be important to this decision are seen in the tales of companies' successes and failures. Researchers have uncovered important aspects of the process (e.g., Contractor and Lorange, 1988; Dodgson, 1993; Hagedoorn, 1993; Harrigan, 1986; Mowery, 1988; Pisano, Shan, and Teece, 1988). However, no research to date has tried to investigate the mental and cognitive processes of top executives

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as they evaluate potential technological collaboration opportunities.

There are a number of reasons why a deeper understanding of executive mental processing should be relevant to both theory and practice. First, researchers report that only a portion of the information available is actually used by executives when they make decisions (e.g., March and Simon, 1958; Simon, 1957; Walsh, 1988). This suggests that collecting information important to a decision does not necessarily mean that it will actually be used by executives during the decision process (e.g., Hitt and Tyler, 1991; Miller, 1956). Secondly, executives develop their own interpretations or mental understandings, largely based on prior experience, which they use to explain events (Hambrick and Mason, 1984; Schwenk, 1984, 1988; Walsh, 1995). Unconsciously they use these to seek and filter information and to create meaning (Starbuck and Milliken, 1988). These mental understandings or models greatly affect the decisions that they make (Schwenk, 1988). However, little is currently known about what information executives use when asked to evaluate technological collaborative opportunities or how executives' beliefs or mental models affect the assessments they are asked to make on behalf of the firm.

This exploratory study seeks to determine what managerial and economic information is actually incorporated into top executive evaluations of technological collaborative scenarios and how cognitive limitations and executive experiences affect these assessments. Hypotheses are developed and tested which suggest that factors associated with normative strategy, transaction cost economics, resource-based theory, risk theory and options theory contribute to an understanding of what information executives should consider when asked to evaluate potential cooperative technological opportunities. Additional hypotheses predicting executive cognitive limitations and heuristics are also tested. Findings from the study are then used to propose an integrated behavioral model that represents the managerial and economic factors executives actually consider when asked to evaluate technological collaborative opportunities and implications are drawn for research and practice. The paper ends with conjectures and speculations in an effort to push the field in new directions.

TECHNOLOGICAL COLLABORATION

Consistent with Dodgson (1993), technological collaboration in this study is defined as *any activity where two or more partners contribute differential resources and technological know-how* [knowledge and skill required to do something correctly] *to agreed complementary aims*. This definition does not include one-way transfers of know-how such as licensing, marketing agreements, or simple one-time only contracts. Rather, technological collaboration is an ongoing arrangement where partners mutually share their expertise and output. It represents a range of alliances between organizations (Borys and Jemison, 1989; Hagedoorn, 1990, 1993; Oliver, 1990; Ring and Van de Ven, 1992). Such relationships may vary in terms of legal contracting and the equity funding provided by the partners. What is common to all of them is the commitment of two or more companies to cooperatively develop technology which will help them keep pace with technological advancements in the marketplace.

There have been many previous attempts to define technology (e.g., Cutler, 1989; Harris, Shaw, and Sommers, 1984). Abetti (1989: 37) perhaps comes closest when he defines technology to be 'a body of knowledge, tools, and techniques, derived from both science and practical experience, that is used in the development, design, production, and application of products, processes, systems, and services'. Technology includes new product innovations as well as new processes or methods by which outputs are generated.

Two dimensions of technology—tacitness and complexity—are particularly relevant to the decision of whether or not to cooperate to develop technology (Polanyi, 1966; Tyre and Hauptman, 1992). Technological knowledge is often tacit—hard to document in writing, and instead resides in individuals, systems, and processes of the firm. This 'embedded' knowledge may not be easily transferred between firms through market mechanisms (Hennart, 1988; Reed and DeFillippi, 1990). However, a tacit understanding of key technologies may affect competitive success. The more the company's understanding of the technology is fully incorporated into the systems and processes of the company (i.e., the more tacit the technological knowledge), the more responsive the company can be in adapting to changes in the technology (Mytelka, 1985).

Complexity refers to the variety and diversity of technologies that must be incorporated into the development process. The more interdisciplinary a technology is, the greater the complexity is thought to be. Today's highly sophisticated innovations often depend upon work across several areas of science and technology (Hagedoorn, 1993). New products or processes may require contributions from such areas as biochemistry, physics, and electronics. Few organizations have the breadth of knowledge required for such undertakings (Radnor, 1991).

The need to have a deep, tacit understanding of a technology and the complex nature of many of today's technologies often make it difficult for organizations to develop technology independently (Radnor, 1991). It is hard to acquire technology based on tacit knowledge in a normal business relationship because such knowledge is often associated with 'learning-by-doing' (Mytelka, 1985). Thus, it can be expected that the greater the tacitness and complexity of the technology the more likely executives will consider technological collaboration as a mode of technological development.

FACTORS AFFECTING TECHNOLOGICAL COLLABORATION

The decision to establish a technological collaborative relationship can be affected by many influences. Allison (1971) and Schwenk (1988) have proposed three general decision models: rational choice and cognitive processes, organizational processes, and political processes. Several root disciplines associated with these three models have contributed to academic theories that have been useful in understanding strategic decision making in a number of organizational settings. In an effort to gain a more comprehensive understanding of the determinants of interorganizational relationships, Oliver (1990) specified five generalizable motives of voluntary relationship formation: legitimacy, reciprocity, stability, efficiency, and asymmetry. The integration of these motives with the three general decision models proposed by Schwenk (1988), and the primary root disciplines associated with them, provide an overview of the wide spectrum of decision theories that can be considered when evaluating the determinants of technological collaborative relationships (see Table 1). This exploratory study, however, seeks to limit its consideration of the motives of technological collaborative relationships to those theories that address rational choice from a managerial or economic perspective or propose cognitive processing limitations or biases (bold portion of Table 1). Although the organizational and political process theories (e.g., institutional theory, resource dependency) have contributed a great deal to the understanding of interorganizational relationships, they are not directly incorporated into this investigation. This study focuses on the individual as a complex information-processing system (March and Simon, 1958) and evaluates managerial, economic, and cognitive explanations for why top executives consider technological collaborative opportunities more or less attractive.

The specific domain selected for the study is primarily a response to calls for strategy research that (1) incorporates both content (deductive economics) and process (cognitive psychology) and (2) seeks to exploit the tension between the rational and suboptimal aspects of human behavior in the next generation of organizational economics research (Mahoney, 1992; Schoemaker, 1990). Thus, it is argued here that informational dimensions associated with five rational-choice lenses represent a rational content focus regarding the factors top executives should consider when asked to evaluate technological collaborative opportunities. However, it is also argued that a content focus does not adequately portray the situation at hand and that cognitive processing limitations are also important considerations in studies of judgments related to cooperative technological development (Auster, 1994; Schoemaker, 1990).

RATIONAL CHOICE LENSES

Top executives must use a number of important factors in their decisions as they evaluate potential technological collaborative opportunities. While some aspects of the decision are related to the specific type of hybrid arrangement considered (Borys and Jemison, 1989; Hagedoorn, 1993)

Table 1. Perspectives on strategic decision making

Perspective	Organizational processes	Rational choice and cognitive processes		Political processes
Root disciplines	Organization theory Sociology	Strategy Cognitive psychology	Economics Finance	Sociology Political science
Motive	Legitimacy	Reciprocity and stability	Efficiency	Asymmetry
Representative theories	Inertia Institutional	Normative strategy Resource-based view Upper echelons	Transaction cost Risk Options	Resource dependency Class hegemony

and others are related to the specifics of the technology to be developed, a number of important factors of a more generalizable nature have been proposed (e.g., Auster, 1992; Harrigan, 1988a, 1988b; Hennart, 1991; Oliver, 1990; Parkhe, 1991). Several of these more generalizable content-oriented factors can be associated with five rational choice lenses used in the strategy literature; normative strategy, transaction cost economics, resource-based theory, risk theory, and options theory (e.g., Hofer and Schendel, 1978; Kogut, 1991; Wernerfelt, 1984; Wernerfelt and Karnani, 1987; Williamson, 1985). These theories are not mutually exclusive and in some respects build upon one another. However, they have in general accepted different assumptions and highlight different aspects of organizational reality.

Normative strategy

Early normative strategy emphasized the need for technology development efforts to match business and corporate level strategies (Pappas, 1984; Porter, 1980, 1983). This focus grew from the strategy literature which suggested a fit between organizational technology and structure and the firm's strategy (Chandler, 1962; Ford, 1988; Lawrence and Lorsch, 1967; Woodward, 1965) and has received some empirical support (e.g., Zahra and Covin, 1993). However, previous research has been inconclusive as to the relationship between the strategic importance of technology and the use of collaborative efforts. Some have found that collaborative technological development occurs in strategically important areas (Baughn and Osborn, 1990; Hagedoorn and Schakenraad, 1992). On the other hand, when the firm's strategy is highly dependent on a given technology, executives may not collaborate for fear of losing control over vital resources (Harrigan, 1986). They may choose instead to develop the technology internally and avoid the risk of transferring important tacit knowledge to potential partners. *Business Week* reports that this is why Europe's largest diesel engine manufacturer, VM Motori, has steered clear of alliances (Coy *et al.*, 1994). Therefore, it can be argued that the attractiveness of collaborative efforts to develop technology will increase with the significance of the technology to strategy up to a point and then decrease as concerns over proprietary control build.

Hypothesis 1a: Normative strategy suggests that the significance of the technology to the company's strategy will be curvilinearly (inverted U-shape) related to top executive assessments of technological collaborative opportunities, all else equal.

Also according to normative strategy, the development of a technology strategy should require an evaluation of internal strengths and weaknesses and external threats and opportunities (e.g., Ansoff, 1965; Hofer and Schendel, 1978). Three important considerations in this type of analysis would then be an evaluation of the existing skills the company has to develop the technology (e.g., Ansoff, 1965; Snow and Hrebiniak, 1980; Steiner, 1979), the life cycle phase of the technology, and compatibility of management styles (e.g., Cairnarca, Colombo, and Mariotti, 1992; Dodgson, 1993; Harrigan, 1988b; Hofer, 1975; Hofer and Schendel, 1978). Depending on the complexity of the technology, the firm may or may not have the requisite skills necessary for development. If executives believe that the firm has the technological skills (perceived strength), logic suggests that they will be *less* likely to consider a cooperative relationship to develop technology. If they think the firm has some of the skills and knowledge required but lacks specific capabilities (perceived strengths and weaknesses), they are more likely to consider a technological cooperative relationship (Moenaert *et al.*, 1990). Finally, if they have very few of the skills and capabilities associated with the technology (perceived weakness), they have little to offer a potential partner and are likely to pursue alternative means of technology acquisition such as licensing or acquiring a company with the desired skills (Roberts and Berry, 1985). These arguments suggest an inverted U-shaped relationship between skill capabilities and the perceived attractiveness of technological collaborative relationships.

Hypothesis 1b: Normative strategy suggests that the existing skill capability of the firm to develop this technology will be curvilinearly (inverted U-shape) related to top executive assessments of technological collaborative opportunities, all else equal.

Likewise, if the technology is in an early stage of its life cycle, firms may see great potential (perceived opportunity) in the use of a cooperative relationship to develop the technology and dictate the direction of industry-wide technological development. In maturity, when market uncertainties are resolved, acquisitions or licensing may be preferred in order to promptly access the existing technology (Auster, 1992; Ford, 1988; Kogut, 1989). In a study of over 2000 agreements in information technology, Cairnarca *et al.* (1992) found collaborative agreements to be more prevalent during introduction, early development, and maturity and less prevalent during full development and decline of the technology life cycle.

Hypothesis 1c: Normative strategy suggests that the more advanced the life cycle phase of the technology, the less attractive technological collaborative opportunities will be to top executives, all else equal.

A final factor is the compatibility of operating and management styles of the company and the potential partner (potential opportunity or threat). This aspect of the proposed partnership is considered relevant as incompatibility may create uncertainties which can cause major strategy implementation problems (Galbraith, 1973; Harrigan, 1988b). Collaborative efforts are inherently hard to manage. Significant differences in structures, systems, and culture can only enhance this difficulty and may render such relationships unsuccessful. Similarity in partner values and methods of conducting business activities allow for easier merging of efforts (Dodgson, 1993). This permits the partners to focus on agreed-upon goals as opposed to any discrepancies in management style. IBM and Rolm Corporation discovered this when their divergent management styles eventually contributed to the breakdown of their collaborative efforts (Levine and Byrne, 1986).

Hypothesis 1d: Normative strategy suggests that the greater the compatibility of operating and management styles of a partner with those of the firm, the more attractive technological collaborative opportunities will be to top executives, all else equal.

Transaction cost economics

Transaction cost theory is grounded in both the notion of bounded rationality and the potential for opportunistic behavior on the part of some individuals or firms (Hill, 1990; Kogut, 1988; Williamson, 1985, 1991). Opportunism can be defined as 'self-interest seeking with guile'. According to Williamson (1985: 47) 'this includes but is scarcely limited to more blatant forms, such as lying, stealing, and cheating'. Due to the limitations resulting from bounded rationality, it is often difficult to distinguish between firms that may behave opportunistically from those likely to maintain a more cooperative stance.

It has been argued that the smaller the number of capable partners for a desired relationship, the lower the bargaining power of the firm relative to any given potential partner (Kogut, 1988; Pisano, 1990; Williamson, 1985). Likewise, the need to invest in assets specific to the cooperative project and of limited value outside the relationship can lead to higher switching or exit costs for the firm (Kogut, 1988; Williamson, 1985). These two factors are particularly pertinent for technology-based relationships. There are generally a limited number of firms capable of providing expertise in advanced technology development or customization (e.g., telecommunications, biotechnology). Leading-edge technology can also require extensive sophisticated training and equipment which may be of limited value outside its relatively narrow domain. Such conditions constrain the opportunities for the firm and may increase its dependence upon the partner (e.g., Pisano, 1990). This dependence can allow the partner to charge excessive prices and perhaps behave opportunistically unless such actions are mitigated through stringent contracting and monitoring (e.g., Tanzer, 1992). It can be argued, then, that the larger the number of other potential partners and the lower the asset-specific investments required, the more attractive a potential technological collaborative opportunity becomes.

Hypothesis 2a: Transaction cost theory suggests that the larger the number of other potential partners for developing technology, the more attractive technological opportunities will be to top executives, all else equal.

Hypothesis 2b: Transaction cost theory suggests that the lower the asset-specific investments required, the more attractive technological opportunities will be to top executives, all else equal.

The distribution of information between technology partners is also likely to be skewed toward one partner over the other. An informational disadvantage pertaining to the technology in question can lead to excessive transaction costs. These transaction costs result from ambiguity over the performance of the partner, which can arise when the object of exchange is complex or intangible (Bowen and Jones, 1986). Assessing the performance of a technology partner can be particularly difficult when the technology contains a level of complexity unfamiliar to the firm but not the partner. Such informational disadvantages can allow for opportunistic behavior on behalf of the partner and lead to increased levels of investment in monitoring mechanisms (Oliver, 1990; Parkhe, 1993; Williamson, 1985). On the other hand, if the potential partner has minimal information regarding the technology, there would be little justification for forming a collaborative relationship. Thus, potential technological collaborative relationships where the firm has little or most of the pertinent information regarding the technology should be less attractive than opportunities where the information is more equally shared.

Hypothesis 2c: Transaction cost theory suggests that relative information advantage will be curvilinearly (inverted U-shape) related to top executive assessments of technological collaborative opportunities, all else equal.

Much has been written of the effects of trust and reputation on cooperation (e.g., Parkhe, 1993; Ring and Van de Ven, 1992). Hill (1990) has argued that in the long run the market will drive out those who behave opportunistically and reward those that cooperate. In the short term, however, opportunism will occur when the perceived pay-offs from such behavior exceed the present value of the costs of acting opportunistically. These costs may include the potential benefits derived from future cooperation with one's current and future partners (Parkhe, 1993). The cooperative history of the potential partner may give some measure of the opportunistic potential of that partner and decrease the need for extensive monitoring and contracting efforts (Parkhe, 1993). For example, Corning Corporation is renowned for making partnerships work (Sherman, 1992). Because of this favorable history, potential partners can be expected to prefer Corning to firms with less favorable cooperative histories.

Hypothesis 2d: Transaction cost theory suggests that the more favorable the potential partner's cooperative history the more attractive technological collaborative relationships will be to top executives, all else equal.

Resource-based theory

Resource-based theory moves beyond normative strategy by considering the *process* of resource accumulation (e.g., learning) and by providing a *method of evaluation* which can predict a specific resource's ability to provide a sustainable competitive advantage (Barney 1991; Collis, 1991; Hamel, 1991). According to the resource-based view, 'sources of sustained competitive advantage are firm resources that are valuable, rare, imperfectly imitable [i.e., hard to imitate], and non-substitutable [i.e., have few substitutes]' (Barney, 1991: 116). A firm's broad-based skills and capabilities (i.e., resources) are often referred to as core competencies (Prahalad and Hamel, 1990). These resources are much harder to acquire, imitate, or substitute than are physical resources and are more likely to provide the company with a longer-term competitive advantage (Dierickx and Cool, 1989; Hall, 1992; Reed and DeFillippi, 1990). An example of such a core competency is Sony's miniaturization skills (Prahalad, 1993), which can provide Sony with a competitive advantage not only in their current product lines but also in future businesses not yet conceived.

Prahalad and Hamel (1990) point to cooperative relationships as one means of internalizing core competencies (i.e., learning) and enhancing competitiveness. These relationships can be used to acquire tacit knowledge from the partner (Kogut, 1988). By neglecting a competency development perspective, a firm limits its opportunity for learning critical skills and may subject itself to further dependency on supplier organizations. In his case study analysis of nine international alliances, Hamel (1991) found that competency development required firms to have an established intent to learn and a view of collaboration as an opportunity to learn.

A primary factor in a firm's ability to develop technology-based competencies from a cooperative venture is the potential to learn from that relationship. This, in part, will be contingent upon both the transparency or openness of the partner's skills and the ability of the firm to absorb them (Hamel, 1991). It will also depend on the tacitness and complexity of the technology. For example, the acquisition of skills associated with tacit technologies requires hands-on experience or 'learning by doing' and will be more difficult to learn than technological skills that can be transferred via documented routines (Reed and DeFillippi, 1990; Tyre and Hauptman, 1992). This may require the high level of interaction found in a collaborative agreement. Furthermore, the value of the technical competencies gained will hinge upon the perceived likelihood of applying such skills on a corporate basis rather than to a narrow product line or market. As discussed above, Sony's miniaturization competency is of competitive value due to its applicability to a broad range of business units and products, and it is critical to the growth of the entire company. Hence, those executives possessing a strong intent for building competency will be concerned with the capacity for learning from the relationship, the degree of 'learning by doing' associated with the technology, and the potential for broad corporate application of the technology.

Hypothesis 3a: Resource-based theory suggests that the greater a firm's capacity for learning from the relationship, the more attractive technological opportunities will be to top executives, all else equal.

Hypothesis 3b: Resource-based theory suggests that the more the technology requires 'learning by doing', the more attractive technological opportunities will be to top executives, all else equal.

Hypothesis 3c: Resource-based theory suggests that the greater the potential for broad corporate application of the technology, the more attractive technological opportunities will be to top executives, all else equal.

While the ability to imitate or substitute a firm's technology is always a matter of degree, if enough firms have these valuable resources or can acquire them no firm can expect to obtain a sustained competitive advantage (Barney, 1991). The degree to which technology can be exploited for current and future success will depend on how easily it can be imitated or closely substituted for by one's rivals (Dierickx and Cool, 1989; Lippman and Rumelt, 1982; Reed and DeFillippi, 1990). From a legal basis, patent restrictions may limit the overt copying of technology and allow the developing firms the opportunity to reap the benefits of the technological advantage (Hall, 1992). Government patent policies create barriers to imitation and provide a source of competitive advantage (Ghemawat, 1986). The probability of substitution of a technology is often hard to predict. Technological change may be evolutionary or revolutionary (Schumpeter, 1934). If it is evolutionary, a well-developed tacit skill base and organizational capabilities associated with the technology are an advantage as the firm seeks to respond and adapt to the changing technology (Leonard-Barton, 1990). However, revolutionary changes may provide technologies that meet the same customer needs but are based on a completely different technological base than the previous technology (e.g., mini mills for integrated steel mills)

Hypothesis 3d: Resource-based theory suggests that the greater the potential for gaining patent protection, the more attractive technological collaborative opportunities will be to top executives, all else equal.

Hypothesis 3e: Resource-based theory suggests that the greater the availability of technological substitutes, the less attractive the technological collaborative opportunities will be to top executives, all else equal.

Risk and options theory

Risk theory and options theory—a subcategory of risk theory—provide additional lenses through which technological cooperative partnerships can be evaluated (e.g., Bowman and Hurry, 1993; Kogut, 1991). According to risk theory, top executives explicitly consider the probabilities of risk and reward associated with investment choices in an effort to maximize their expected utility (Kahneman and Lovallo, 1993) and the expected value of a technological collaborative relationship can be defined as the (probability of success × value of success) + (probability of failure × value of failure). Risk theory also proposes that actions that increase the probability of success will have value. Since success is positive and failure negative a collaborative relationship that increases the probability of success will have positive value. Companies may through technological collaboration gain valuable experience and skills which lower development risk and thus improve the probability of success. Such is often the case when two or more firms with related skills (e.g., biotechnology and chemistry) combine those skills to develop technology. In these situations the expertise of the various firms cause the combined effort to have a higher probability of success than would be the case if a single firm tried to develop the technology alone. Collaborative technological opportunities that are expected to increase the probability of success would, therefore, be considered attractive.

Hypothesis 4a: Risk theory suggests that the greater the potential for decreasing development risk, the more attractive technological collaborative opportunities will be to top executives, all else equal.

Portfolio arguments of risk theory suggest that executives and organizations should prefer investing in a number of small projects over a single investment of equal expected value, since small investments will contribute far less to the variability of the entire portfolio of investments than the large investment (Bowman and Hurry, 1993; Kahneman and Lovallo, 1993). Thus, having a portfolio of projects reduces the overall risk for a company. Given a limited amount of money to invest in R&D (Tyler, 1992), executives responsible for allocating these resources can be expected to invest in a portfolio of R&D projects that limits the company's risk. Collaborative opportunities allow firms to invest limited resources into more projects than would be possible through internal development, consequently lowering risk. It can be argued, therefore, that the higher the expected cost to develop a technology, the more attractive collaborative technological relationships would be to top executives.

Hypothesis 4b: Risk theory suggests that the greater the expected cost for developing the technology, the more attractive technological collaborative opportunities will be to top executives, all else equal.

Options theory extends the concept of risk taking under uncertainty to a consideration of strategic flexibility afforded firms that purchase a portfolio of options (Sanchez, 1993). Options are investments to retain the right to future investment choices without being obligated to invest (Bowman and Hurry, 1993). An option contract allows an investor (individual or firm) to make an investment to buy an option, hold it until the opportunity arrives, and then decide between buying the option (i.e., striking the option) to capture the opportunity or abandoning it.

For a given expected cost for development, a technological collaborative relationship that allows those costs to be committed incrementally contingent on positive income outcomes will be more attractive than those in which costs must be committed up front. A project of this sort can be thought of as a series of options where the firm can stop buying subsequent options contingent on the outcomes of the collaboration. IBM's venture with Philips Electronics to own and operate an IBM chip plant in Germany is an example of such an option. Although this is currently a joint manufacturing agreement, the partners are discussing a broader relationship under which they would jointly design chips for consumer products (Ziegler, 1994).

Hypothesis 4c: Options theory suggests that the greater the degree to which cost commitments for a technology can be made contingent on outcomes, the more attractive technological collaborative opportunities will be to top executives, all else equal.

While there is some value in waiting for a technology to be proved, there is also a benefit in investing today in order to gain experience and obtain the option to expand in the future (Kogut, 1991). Companies may through technological collaboration develop strong working relationships and gain valuable experience and skills which increase their exposure to related market opportunities and their ability to sense and respond to new opportunities (Cohen and Levinthal, 1990; Kogut and Zander, 1992). In these situations the knowledge obtained through the partnership (e.g., special knowledge regarding a new market or the newest development in a base technology) increases the number of future options available to the firm.

Hypothesis 4d: Options theory suggests that the more technological collaboration can increase the potential for related market opportunities, the more attractive technological collaborative opportunities will be to top executives, all else equal.

The theoretical arguments presented above suggest 'content'-related informational dimensions that should be important to top executives in their evaluations of potential technological collaborative opportunities. However, strategic decisions are also influenced by 'process'-related factors which include the decision process itself and the factors that affect it (Schwenk, 1995).

COGNITIVE PROCESSES

It has been acknowledged for some time that the individuals making decisions within organizations are rationally bounded (Simon, 1957). This means that although individuals may intend to evaluate information rationally, they are not able to incorporate all the information available in their decision model due to cognitive limitations (e.g., Miller, 1956; Schwenk, 1994). These limitations affect the simplified mental models or schema top executives use to get a grasp of the situation at hand (Schwenk, 1984; Walsh, 1995), thus affecting the search, perception, and incorporation of information during strategic decision making (Starbuck and Milliken, 1988; Walsh, 1988). While cognitive processing limitations may at times result in poor decisions, current development and cognitive theorizing suggest that the use of schema is necessary in any perceptual act. Schemata and heuristics provide executives with needed selection criteria and guidelines for processing in order to choose information that is useful and process it efficiently (Schwenk, 1988). Given the bounds of rationality, executives cannot hope to process all the information available (e.g., March and Simon, 1958; Miller, 1956). Some accessible information may be thought to be irrelevant or redundant and executive time is at a premium. The marginal value of the improved quality of a strategic decision may not be worth the cost in time and resources required for a more thorough analysis.

Top executives involved in evaluating potential technology-related cooperative partnerships should be behaviorally constrained by the limits of rationality outlined above. Considering the need to cognitively process information associated with a number of important issues, top executives can be predicted to apply simplified decision models. If top executives cannot use all the information regarded as important to technological collaborative opportunities, an assessment of what information top executives actually utilize in their evaluations can give a more accurate description of managerial decision making than academic theoretical prescriptions. These arguments suggest the following hypothesis.

Hypothesis 5a: Top executives will use a limited number of available informational dimensions in their evaluations of technological collaborative opportunities.

The schema top executives use when asked to evaluate technological collaborative opportunities are the cumulative result of many forces and events in the past, the present, and those anticipated in the future (Bateman and Zeithaml, 1989). However, prior direct examinations of executive mental models have been limited largely by the challenges associated with capturing and mapping these models (Huff, 1990; Walsh, 1995). In an effort to avoid many of the complexities associated with executives' psychological orientations a stream of research, labeled upper echelons theory, has looked at the effects of executive background characteristics on the strategic decision process (Hambrick and Mason, 1984).

Upper echelons theory

Hambrick and Mason (1984) suggested that observable demographic characteristics of top executives could be used to infer their basic beliefs and values and that these belief systems could affect firm level strategic decisions. Many of the demographic characteristics proposed and investigated are argued to represent the experience base of the executive (e.g., age, industry tenure). Research has provided some support for these arguments but has recognized that executive effects are somewhat constrained by environmental, organizational, and decision-specific factors (Hambrick and Finkelstein, 1987; Hitt and Tyler, 1991). Moreover, researchers have found that characteristics of key organizational actors are related to innovation broadly construed (Kimberly and Evanisko, 1981), and, more specifically, to technological innovation (Ettlie, 1983; Hoffman and Hegarty, 1993) and R&D investment decisions (Tyler, 1992, 1994).

Ireland *et al.* (1987) found that strategic decision processes varied by the manager's level in the firm. More specifically, they found that managers at different levels had distinctly different perceptions of the firm's strengths and weaknesses and of environmental uncertainty. They speculated that these differences resulted from the fact that executives have different types and amounts of information available for strategic decision making. These arguments can be applied to executives asked to evaluate technological cooperative relationships. CEOs, by virtue of their office, are responsible for taking a long-term perspective when making strategic choices for the firm. They are usually the firm's visionary, chief strategic planner, primary boundary spanner, and the most powerful individual in the organization (Hambrick and Finkelstein, 1987; Finkelstein, 1992). The CEO can be expected to have a greater understanding of the long-term implications of collaborative relationships, a greater sense of strategic control, and experience less pressure regarding financial resource limitations than executives further down in the organization. As executives move progressively down in the organization, they can be expected to have a more focused perspective and less strategic control over actions taken by the firm and resource allocations (Burgelman, 1983). They can, therefore, be expected to be less critical in their assessments of specific potential technological collaborative relationships than the CEO.

Hypothesis 5b: The level of executives affects their evaluation of technological collaborative opportunities.

Dearborn and Simon (1958) found that executives defined problems largely in terms of the goals and tasks in their respective functional areas. These and other findings motivated Hambrick and Mason (1984) to suggest that top executives in different types of functions develop distinctly different orientations to the firm and its environment. Melone (1994) found that vice-presidents of corporate development tended to be more optimistic in their evaluations of acquisition candidates than chief financial officers. An application of these general principles to assessments of technological collaborative relationships predict differences in evaluations based on executive functional experience. For example, executives with primary functional experience in engineering or R&D can be expected to see collaboration as an excellent opportunity to gain expertise and as an avenue to new and exciting technological directions. It can be argued that they will be relatively positive regarding the potential collaboration. Executives with dominant experience in accounting and finance can be expected to be more critical of such opportunities.

Hypothesis 5c: Top executives' dominant functional experience affects their evaluation of technological collaborative opportunities.

Fredrickson (1985) found that the decision processes of experienced managers differed greatly from those used by inexperienced managers in making strategic decisions. It appeared that the less experienced executives were more naive and did not yet have the benefit of a knowledge base developed over time from multiple past experiences. In support of these arguments, Tyler (1994) found that CEO position and company tenure moderated firm-level investments in R&D. Her results suggest that firms with CEOs early in their tenure tend to experiment more with R&D investments than firms with CEOs having longer tenures. Hambrick, Geletkanycz, and Fredrickson (1993) found a similar association between executives' tenure in an industry and commitment to the status quo in company leadership and strategy. They found support for the contention that industry norms exist and that executives tend to adhere psychologically to them more and more the longer they are in the industry (Hambrick, 1982; Spender, 1989).

Executive experience in an industry (industry tenure), thus, can influence the type of information that is focused upon when evaluating technological collaborative opportunities. When executives have limited industry experience, they may attempt to evaluate cognitively much of the information avalable and weigh it fairly equally because they do not know the relative importance of the various informational components. Over time, however, they can be expected to learn what the most important factors are for their industry and to adopt simplified models accepted as appropriate by industry participants (Spender, 1989).

Hypothesis 5d: The length of time the top executive has been in the industry will influence the type of information used in evaluating technological collaborative relationships.

METHOD

Sample

Data were acquired through a survey instrument mailed to top executives having graduated from either a large midwestern university or a small prestigious engineering school. These institutions were selected for the variance provided in the degree types awarded to their graduates. A random sample of 130 executives from the large midwestern university was generated from an alumni list of 1076 graduates holding top executive titles in companies participating in industries where technological development is a consideration (manufacturing, utilities, and software development, two-digit SIC codes 20–39, 49, and 73). The same criteria were used to select the executives graduating from the engineering school. However, no random sampling was necessary because only 105 executives met these criteria. To ensure the appropriateness of each sample, each executive was contacted by phone and asked if they were likely to be involved in decisions concerning shared or cooperative technology development within their organization. Only those executives indicating that such a judgment would be within the realm of their decision-making authority were included in the sample. Of the 235 contacted, a total of 168 executives were found to be appropriate (indicated that such a judgment would be in their decision-making authority) and agreed to complete the survey.

Of the 168 surveys mailed, 101 were returned for an overall response rate of 60 percent. The two institutions had individual response rates of 61 percent and 58 percent (midwestern university and engineering school respectively), suggesting little response bias resulting from school affiliation. Five responses were found to have missing data. Information obtained on the questionnaire of three additional surveys suggested that the firms the executives worked for were not within the appropriate industries. A follow-up telephone call confirmed this and they were dropped, leaving a preliminary usable sample of 93. The average age of the 101 respondents was 49 with a mean of 26 years of work experience; 34 percent held the position of CEO or president; 8 percent were senior vice-presidents while another 41 percent were vice-presidents; 71 percent had previous experience selecting technology partners. Of the nonrespondents 32 percent held the top position, 13 percent were senior vice-presidents, and 42 percent were vice-presidents, suggesting minimal systematic differences in terms of position between respondents and nonrespondents. The only significant difference in industry sector between respondents and nonrespondents was from the electrical equipment sector (3600) which made up 14 percent of the respondents and only 7 percent of the nonrespondents. Sixteen industries were represented in the usable sample ($N = 93$), with average annual sales of $723 million.

Instrument

The instrument contained two parts including 30 scenarios of potential technological collaborative relationships described through 17 criteria (discussed below) and a set of questions regarding the individual respondent and firm characteristics.[1] The sequence of the instrument sent to the executive was randomly determined to control for potential order effects.

Executive characteristics

Executives were asked to report the number of levels between them and their firm's CEO. The further the executive was from the CEO, the higher the number (CEO = 0). In addition, they were asked to denote their primary work experience by marking one of five categories: engineering and R&D, general management, finance and accounting, marketing, or other. Each was coded as a dummy variable in the analysis. The executives also provided the number of years they had worked in the firm's primary industry.

Control variables

Two sets of variables representing industry categories and size were used as partial control for main effects associated with institutional and inertial processes. During the initial telephone screening, executives were asked to provide information on the primary industry in which their firm participated. This information was used to assign two-digit SIC codes to each executive's profile. Research suggests that size will be curvilinearly related to measures of innovation (Damanpour, 1992; Ettlie, 1983). It can be argued that collaborative activities represent a form of organizational innovation. Therefore, the natural log of annual sales in millions and its squared term were used to control for size effects.

Decision models

The method of policy capturing was used to determine the decision model being applied by each executive in evaluating potential technological collaborative opportunities (Slovic and Lichtenstein, 1971).[2] Researchers have concluded that individuals typically do not have an accurate understanding of the actual decision rules they follow when making a decision (Sherer, Schwab, and Heneman, 1987; Viswesvaran and Barrick, 1992). Hence, studies based on policy-capturing judgments are believed to tap into the underlying cognitive process of the respondent more objectively than studies using self-report methods. Furthermore, policy capturing has the potential for reducing social desirability biases as compared with other self-report techniques (Schwab, Rynes, and Aldag, 1987). More specifically, post hoc interviews performed in a study by Hitt and Middlemist (1979) revealed that policy-capturing models accurately represented actual decision-making behavior, providing support for the external validity of the procedure.

Initially the authors reviewed the literature on the five content-oriented theories and selected a limited set of primary considerations put forth by the theories. They then reviewed the literature on technology and collaboration and developed

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[1] The use of 30 cases has precedence in the literature (Hitt and Middlemist, 1979; Ireland *et al.*, 1987; Hitt and Tyler, 1991). Thirty cases allow for adequate within-subjects analysis while limiting subject fatigue.

[2] This methodology, which has been broadly utilized in previous organizational research to model managers' decision processes (e.g., Hitt and Middlemist, 1979; Hitt and Tyler, 1991; Sherer *et al.*, 1987), is similar to a repeated-measures design and allows assessment of actual 'theories in use' as opposed to 'espoused theories in action' (Argyris and Schon, 1974). Policy capturing requires subjects to evaluate a series of scenarios within the context of their organization. Using regression, the executive decisions made regarding each scenario can be aggregated and quantified into a decision model identifying influential criteria.

initial informational factors believed to be representative of the theoretical dimensions and important to technological collaboration. Next, interviews to discuss the factors and their rationale were conducted with five top executives and five academics who either were involved in this type of collaboration or had read and/or published in this area. This led to a set of factors which were pilot tested as described below. Revisions suggested during piloting were made, resulting in 17 factors. The sequence in which the information was listed in the actual scenarios was randomly determined (the order was consistent for all 30 scenarios). The 30 different scenarios were developed by randomly assigning each of the 17 criteria a number on a scale ranging from one (low) to five (high). The random assignment creates very diverse technological collaborative opportunities while limiting the potential for collinearity between the criteria. The correlation matrix for the criteria and the dependent variable can be seen in Table 2. The highest correlation was $r = 0.55$ with 96 percent of the pairwise *r*s below 0.40. This suggests that the criteria are sufficiently independent and free of collinearity. A sample of one of the scenarios used in the study (AF) is provided in the Appendix.

Each executive was mailed the same 30 scenarios and asked to evaluate them and rate both the attractiveness of the relationship and the probability that they would pursue such a relationship on a seven-point Likert scale ranging from 1 (very low) to 7 (very high). The numbers reported for these two questions were added together to create the dependent variable, 'evaluation of the opportunity' (alpha = 0.95). The resulting returns of 93 surveys equated into a sample size of 2790 observations (93 × 30). The assumption that each case represents an independent observation has previously been accepted (e.g., Hitt and Middlemist, 1979; Hitt and Tyler, 1991).[3]

Pilot study

The instruments used were piloted with both executives involved in an executive development program and part-time executive MBAs. The data were analyzed and individual and group results were made available to participants. The executives were subsequently debriefed to assess the interpretation and the viability of each of the decision factors in the policy-capturing scenarios and the other questions. Any discrepancies between intended interpretation and actual interpretation were addressed by altering the wording of the criteria or questions in the final questionnaire.

RESULTS

Each executive's model for determining the attractiveness of a technological collaborative opportunity was initially determined based upon his or her reponse to the 30 scenarios. Because of the limited degrees of freedom ($n = 30$ and 17 independent variables), stepwise regression was used. This procedure entered only the information that was statistically significant at $p < 0.05$. The explained variance reported for the individual models, using this procedure, represents each subject's internal consistency while evaluating the 30 collaborative opportunities. This analysis produced explained variances ranging from $R^2 = 0.0$ to $R^2 = 0.91$ across all executives. The median R^2 was 0.57. The complexity of the individual models ranged from no significant criteria to eight independent criteria entering into an individual model.

Conforming with the works of Hitt and Middlemist (1979) and Keats (1991), those executives failing to generate a model explaining a minimum level of variance ($R^2 < 0.40$) were viewed as giving inconsistent managerial ratings and may not have perceived independence among the dimensions. Twenty-one individual models

[3] To further verify the independence of the observations, the serial correlation among the within-person observations was examined. Dummy variables were created for each respondent and used to block within-person variance while determining the remaining variance explained by the 17 criteria (Hitt and Tyler, 1991). Hierarchical regression was used to determine the variance explained by the criteria over and above that explained by the control and individual dummy variables. The objective criteria were found to explain 27 per cent of the variance (full model $R^2 > 0.347$) beyond the set of individual dummy variables ($R^2 = 0.074$). These results are consistent with previous research of this type (e.g., Hitt and Tyler, 1991) and suggest that the data are relatively free of serial correlation. Further analysis on the aggregated and ordered data presented nonsignificant Durbin–Watson and Box–Pierce Q-statistics affirming limited correlated error and the robustness of subsequent OLS regressions.

Table 2. Intercorrelation matrix for objective criteria and the evaluation of the opportunity

Variable	Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Significance to strategy	3.17	1.37	–																	
2. Life cycle phase	2.87	1.50	0.24	–																
3. Existing skill capability	2.97	1.45	−0.01	0.46	–															
4. Importance of 'learning by doing'	2.54	1.26	0.08	−0.32	0.01	–														
5. Total expected cost	3.27	1.41	0.12	0.36	0.10	−0.21	–													
6. Number of potential partners	2.60	1.28	−0.34	−0.20	0.03	0.05	0.13	–												
7. Required asset specific investments	3.07	1.44	0.11	−0.09	−0.1	0.15	0.25	0.36	–											
8. Favorability of partner's history	3.37	1.38	0.23	0.25	0.01	−0.07	0.00	−0.20	−0.16	–										
9. Potential for corp. application	3.53	1.31	−0.07	−0.13	0.39	0.19	−0.22	0.11	−0.18	−0.09	–									
10. Patent protection	2.90	1.45	0.01	−0.11	−0.03	0.49	−0.22	0.30	0.07	0.02	0.10	–								
11. Decreased development risk	3.57	1.31	0.04	−0.06	0.10	−0.02	0.12	0.10	0.10	0.09	−0.16	−0.15	–							
12. Info. advantage	2.63	1.40	−0.09	0.25	0.24	0.20	−0.22	−0.03	−0.14	0.21	0.16	0.44	−0.21	–						
13. Potential for learning	2.87	1.43	0.30	0.01	−0.07	−0.18	0.13	−0.32	−0.14	−0.11	−0.10	−0.44	0.29	−0.10	–					
14. Availability of tech. substitutes	3.13	1.38	−0.17	0.02	0.22	0.27	0.07	0.20	0.55	−0.03	0.03	0.21	0.14	0.04	−0.24	–				
15. Market exposure	3.13	1.45	0.01	0.10	0.05	−0.24	0.03	−0.10	−0.30	0.19	0.10	−0.01	0.12	0.07	−0.04	−0.34	–			
16. Partner compatibility	3.07	1.46	−0.14	−0.18	0.00	0.11	−0.09	−0.09	−0.08	−0.10	−0.26	0.08	0.07	−0.04	−0.33	0.12	0.12	–		
17. Contingency of costs	2.70	1.49	0.04	0.04	−0.30	−0.31	−0.17	−0.20	−0.10	−0.26	−0.21	−0.22	−0.10	−0.31	0.00	−0.26	−0.09	0.13	–	
18. Evaluation of the opportunity	7.16	3.46	0.38	−0.05	−0.10	0.08	−0.17	−0.28	−0.21	0.18	0.04	0.06	0.08	0.03	0.12	−0.22	0.18	0.15	0.01	–

failed to meet this minimum, leaving a usable sample of 72 executives or 2160 observations.[4] The average number of significant factors per subject for the final sample was 3.7, while the explained variances ranging from $R^2 = 0.40$ to $R^2 = 0.91$ (the median R^2 was 0.68).

The observations from the remaining 72 subjects were aggregated and used to test the hypotheses. Table 3 reports the means, standard deviations, and Pearson product–moment matrix of the dependent, control, and executive characteristic variables for the sample ($N = 2160$). Hierarchical regression analysis was used to test Hypotheses 1a–4d. Industry and sales variables were entered into the regression in the first step and accounted for 1.9 percent of the total variance in executive evaluations of technological collaborative opportunities (Table 4). The 17 theoretical dimensions were entered into the model as a block in the second step. This block of factors accounted for an additional 31.3 percent of the variance in the executive evaluations ($F = 48.83$; $p < 0.0001$).

Hypotheses 1a–d, 2a–d, 3a–e, and 4a–d were then tested by inspecting the t-statistic and direction of the individual factors within this model.[5] Hypotheses 1a–d posed specific relationships between informational dimensions and the dependent variable as suggested by normative strategy. Hypothesis 1a proposed a positive linear relationship up to a point and then decreasing thereafter, between executive evaluations and information regarding 'the significance of the technology to current strategy.' To test for Hypothesis 1a, the significance and direction of the squared term of the factor was considered. The squared term is significant ($t = -2.12$, $p < 0.05$). Furthermore, second-order conditions of the model suggest the concave relationship to the dependent variable as predicted. Hence, Hypothesis 1a is supported. Hypothesis 1b also argued for a curvilinear relationship between 'existing skill capability to develop the technology' and executive evaluations. However, as seen in Table 4, neither the factor nor the square of the factor is significant ($t = -1.13$ and $t = 1.18$ respectively) at the 0.05 level. Thus, Hypothesis 1b is not supported. Hypothesis 1c maintained that there was a negative direct effect of 'life cycle phase of the technology' on executive evaluations. This factor produced a significant t-value ($t = -2.34$; $p < 0.05$), providing support for this hypothesis. Finally, Hypothesis 1d, suggesting a positive relationship between 'compatibility of management styles' and executive evaluations, was likewise supported ($t = 4.01$, $p < 0.0001$).

Hypotheses 2a–d set forth information believed to be relevant to assessments of collaborative opportunities according to transaction cost theorizing. Hypothesis 2a inferred a positive relationship between the 'number of other potential partners' and executive evaluations. The associated t-statistic ($t = -1.39$) is not significant at the 0.05 level and thus Hypothesis 2a is not supported. As proposed by Hypothesis 2b, information regarding 'level of asset-specific investments required' is shown to be negatively related to the dependent variable and significant ($t = -3.54$, $p < 0.001$). Support is also found for Hypothesis 2c, suggesting a curvilinear relationship between 'information relative to partner' and executive evaluations ($t = -1.97$, $p < 0.05$). Second-order conditions confirm the concave relationship. The final transaction cost argument, 'favorability of potential partner's cooperative history', is also seen to be positively related to executive evaluations ($t = 3.01$, $p < 0.01$), supporting Hypothesis 2d.

Relationships suggested by resource-based theory were posed in Hypotheses 3a–e. Table 4 reports that the 'potential to learn from the relationship' is not significantly related to the dependent variable ($t = -0.28$). Thus, Hypothesis 3a is not supported. Similarly, Hypothesis

[4] Further analysis was conducted to determine if there was a bias between those subjects being removed and those attaining the minimum level of variance explained. No significant difference in age, position, or industry experience between the two sets of executives was found. Analyses including all 93 executives were not substantially different than those reported for the subsample ($N = 72$) with consistent judgment policies in regard to the factors found to be significant. The primary difference was that the R^2 explained using the aggregated sample was lower. Ad hoc discussions with 13 of the 21 subjects deemed inconsistent found that a number of these performed the policy-capturing exercise when they were pressed for time and perhaps did not give it adequate consideration and a few found the policy-capturing exercise somewhat confusing. A couple noted that the inconsistency was understandable because assessments of technological collaborative opportunities are complex and that there is not even agreement on what the criteria for evaluation should be within their firm.

[5] The authors acknowledge the fact that the number of tests conducted have increased the chance of committing a Type I error. However, due to the exploratory nature of the study the 0.05 probability level was used.

Table 3. Intercorrelation matrix for evaluation of the opportunity, industry, scale, executive level, industry experience, and functional experience

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. Evaluation of the opportunity	7.16	3.46	–																						
2. Food and kindred products	0.03	0.17	−0.02	–																					
3. Apparel and fabrics	0.01	0.12	0.02	−0.02	–																				
4. Paper and allied products	0.01	0.12	0.05	−0.02	−0.01	–																			
5. Chemical and allied products	0.15	0.36	−0.01	−0.07	−0.05	−0.05	–																		
6. Petroleum reading	0.07	0.26	0.01	−0.04	−0.03	−0.03	−0.12	–																	
7. Rubber and plastics	0.04	0.20	0.01	−0.03	−0.02	−0.02	−0.09	−0.06	–																
8. Fabricated metal products	0.04	0.20	0.02	−0.03	−0.02	−0.02	−0.09	−0.06	−0.04	–															
9. Industrial machinery/ computer equipment	0.08	0.28	−0.05	−0.05	−0.04	−0.04	−0.13	−0.08	−0.06	−0.06	–														
10. Electrical equipment	0.15	0.36	−0.02	−0.07	−0.05	−0.05	−0.18	−0.11	−0.09	−0.09	−0.13	–													
11. Transportation equipment	0.11	0.32	−0.05	−0.06	−0.04	−0.04	−0.15	−0.1	−0.07	−0.07	−0.11	−0.15	–												
12. Instruments, medical goods	0.06	0.23	0.00	−0.04	−0.03	−0.03	−0.10	−0.07	−0.05	−0.05	−0.07	−0.10	−0.09	–											
13. Miscellaneous manufacturing	0.07	0.26	0.02	−0.05	−0.03	−0.03	−0.12	−0.07	−0.06	−0.06	−0.08	−0.12	−0.10	−0.06	–										
14. Electric, gas utilities	0.14	0.35	0.07	−0.07	−0.05	−0.05	−0.17	−0.11	−0.08	−0.08	−0.12	−0.17	−0.14	−0.10	−0.11	–									
15. Software development	0.03	0.17	0.01	−0.03	−0.02	−0.02	−0.07	−0.05	−0.04	−0.03	−0.05	−0.07	−0.06	−0.04	−0.05	−0.07	–								
16. Size	5.41	2.72	−0.01	0.16	0.03	0.07	−0.10	0.27	−0.26	−0.10	−0.07	0.02	0.30	−0.10	−0.28	0.13	−0.17	–							
17. Size^2	36.60	31.38	−0.04	0.17	0.00	0.04	−0.09	0.29	−0.21	−0.12	−0.06	−0.01	0.35	−0.09	−0.23	0.06	−0.16	0.96	–						
18. Executive level	0.81	1.17	0.01	0.10	−0.08	0.22	0.00	0.05	−0.14	−0.14	0.05	−0.06	0.25	−0.12	−0.19	0.07	−0.04	0.56	0.58	–					
19. Industry experience	20.51	10.87	0.01	−0.16	−0.14	0.17	−0.01	0.19	0.00	−0.13	−0.04	0.28	−0.07	−0.02	−0.23	0.07	−0.16	0.28	0.27	0.09	–				
20. Engineering and R&D	0.25	0.44	0.09	−0.10	−0.07	0.20	−0.07	−0.16	−0.12	−0.12	−0.06	0.11	0.00	0.00	−0.16	0.32	0.10	0.05	−0.01	0.18	0.40	–			
21. General management	0.19	0.40	0.00	0.13	−0.06	−0.06	−0.11	−0.13	0.25	0.07	−0.02	0.18	−0.06	0.03	0.00	−0.10	−0.08	−0.19	−0.15	−0.22	0.09	−0.28	–		
22. Finance/accounting	0.26	0.44	−0.09	−0.10	−0.07	−0.07	0.10	0.08	−0.12	0.03	−0.07	−0.08	0.09	−0.01	0.21	−0.06	−0.10	0.01	0.01	−0.04	−0.39	−0.35	−0.29	–	
23. Marketing	0.17	0.37	0.04	−0.08	0.26	−0.05	0.12	0.17	−0.09	0.09	0.27	−0.08	−0.16	−0.11	0.02	−0.18	−0.08	−0.06	−0.07	−0.02	−0.07	−0.26	−0.22	−0.27	–
24. Other	0.12	0.33	−0.03	0.19	−0.05	−0.05	−0.04	0.06	0.13	−0.08	−0.11	−0.16	0.13	0.09	−0.10	−0.03	0.19	0.21	0.25	0.10	−0.03	−0.22	−0.19	−0.23	−0.17

Table 4. Hierarchical regression model including information from all four theoretical bases

	Hypothesis	Relationship	Q′	Beta	t-stat.	R^2	ΔR^2
First step: Controls							
Industry (14 categories)							
Natural log of sales (NLS)							
$(NLS)^2$						0.019	0.019
Second step: Informational dimensions							
Significance of this technology to current strategy	1a	C	1	0.87	3.86****		
(Significance of this technology)^2				−0.45	−2.12*		
Existing skill capability to develop technology	1b	C	3	−0.17	−1.13		
(Existing skill capability)^2				0.17	1.18		
Life cycle phase of the technology	1c	−	2	−0.10	−2.34*		
Compatibility of management styles	1d	+	16	0.16	4.01****		
Number of other potential partners	2a	+	6	−0.05	−1.39		
Level of asset-specific investments required	2b	−	7	−0.19	−3.54***		
Information availability relative to partner	2c	C	12	0.34	1.90		
(Information availability)^2				−0.32	−1.96*		
Favorability of potential partner's cooperative history	2d	+	8	0.08	3.01**		
Potential to learn from the relationship	3a	+	13	−0.01	−0.28		
Importance of 'learning by doing' of the technology	3b	+	4	0.03	0.83		
Potential for broad corporate application	3c	+	9	0.04	1.09		
Ability to patent protect the technology	3d	+	10	0.03	0.76		
Availability of technological substitutes	3e	−	14	−0.00	−0.02		
Potential for decreasing development risk	4c	+	11	0.10	4.00****		
Total expected cost for development	4a	+	5	−0.11	−3.74***		
Contingency of cost commitments on outcomes	4b	+	17	−0.03	−0.80		
Increased exposure to related markets	4d	+	15	0.10	3.57***	0.332	0.313

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$
′ criteria number on policy-capturing questionnaire

3b implied a positive relationship between the 'importance of learning by doing of the technology' and executive evaluations. Though in the direction as predicted, this dimension was not significant ($t = 0.83$). Hypothesis 3c suggests a positive relationship concerning the 'potential for broad application' and the dependent variable. As seen in Table 4, this was also not supported by the analysis ($t = 1.09$). The 'ability to patent protect the technology' was conjectured to positively influence executive evaluations in Hypothesis 3d. Likewise, the t-statistic ($t = 0.76$) does not provide ample support for this hypothesis. A final informational dimension proposed by resource-based theory, 'availability of technological substitutes', is also not significantly related to the executive evaluations ($t = -0.02$), providing no support for Hypothesis 3e.

Hypotheses 4a–d proposed information relevant to executive evaluations of technological collaboration according to risk and options theory. The 'potential for decreasing development risk' was suggested to be positively related to executive evaluations in Hypothesis 4a. The results from Table 4 provide support for this hypothesis ($t = 4.00$, $p < 0.0001$). Hypothesis 4b infers that information regarding the 'total expected cost for development' will be positively related to the dependent variable. The t-value (−3.74) for this variable is significant ($p < 0.001$) but is not in the hypothesized direction. Thus, Hypothesis 4b is not supported. Hypothesis 4c argued for a positive relationship between the 'contingency of cost commitments on outcomes' and the dependent variable. This was also not supported ($t = -0.80$). The potential for 'increased exposure to related markets' was hypothesized to positively influence executive evaluations. The t-statistic is significant ($t = 3.57$, $p < 0.0001$) and in the anticipated direction, supporting Hypothesis 4d.

To test Hypothesis 5a (that executives would use a limited number of the informational dimensions in the evaluation) the number of dimensions significantly associated with the evaluations can be counted in the hierarchical regression reported in Table 4. As shown, nine of the 17 factors were significant at the 0.05 level while seven factors were significant at the 0.01 level, providing support for Hypothesis 5a. Hypotheses 5b and 5c maintain that the level of the executive and primary executive functional experience will directly influence the executive evaluation of collaborative opportunities. To test Hypotheses 5b and 5c, separate hierarchical regression models were created for executive level and primary functional experience. For executive level, the level variable was entered after the control variables and situation-specific factors. Likewise, the dummy variables associated with executive functional experience were entered as a block following the controls and specific factors. Model 1, Table 5 indicates that executive level explains 0.2 percent of the variance in the dependent variable over and above the control variables and situation-specific information. The change in the F-statistic ($F = 6.37$) was significant at the 0.05 level. Based upon the direction of the t-statistic ($t = 2.52$) the lower the executive is within the firm's hierarchy, the more likely the executive will perceive technological opportunities as attractive. Hence, Hypothesis 5b is supported. Model 2, Table 5 reports that primary functional experience accounts for 1.2 percent of the variance after the control variables and situation-specific dimensions. This change in R^2 is significant at the 0.0001 level ($F = 9.78$), supporting Hypothesis 5c. By examining the t-statistics of the dummy variables, it is seen that those executives with primary experience in engineering and R&D ($t = 2.72$, $p < 0.01$), as well as those with a marketing perspective ($t = 2.47$, $p < 0.05$), rated the collaborative opportunities higher overall. Though not significant, those executives from a finance and accounting perspective appear to rate such opportunities lower ($t = -1.27$).

Hypothesis 5d suggests that executives will utilize different information in evaluating technological collaboration depending on the executive's tenure in a given industry. To test this hypothesis, a hierarchical moderated regression model was created. The results of this model can be seen in Table 5, Model 3. Interaction terms were generated between industry tenure and the various factors used to describe the collaborative opportunity and were entered into the model following all other variables. The change in R^2 accounted for by the interaction terms is 1.1 percent and is significant at the 0.05 level ($F = 1.77$), providing support for Hypothesis 5d.

Table 5. Hierarchical regression models for executive predictors of assessments of technological collaboration

Independent variable	Model 1 R^2	Model 1 ΔR^2	Model 1 ΔF	Independent variable	Model 2 R^2	Model 2 ΔR^2	Model 2 ΔF	Independent variable	Model 3 R^2	Model 3 ΔR^2	Model 3 ΔF
Industry, size, specific information	0.332			Industry, size, specific information	0.332			Industry, size, specific information, industry tenure	0.332		
Executive level	0.334	0.002	6.37*	Functional experience (five categories)	0.344	0.012	9.78****	Tenure × information	0.343	0.011	1.77*

* $p < 0.005$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

DISCUSSION

The primary objective of this research effort was to assess current academic and practitioner arguments regarding the information top executives should attend to when evaluating technological collaboration opportunities and then test to see what information executives actually utilize in their judgments. The theory section of the paper argued that important factors associated with managerial and economic theories grounded in the rational-choice perspective of strategic decision making can contribute to an understanding of the factors that should be of concern to top executives. The results of the study suggest that (1) executives do not incorporate all available information into their decision models, (2) no single theoretical lens adequately represents the informational dimensions considered relevant in evaluations of technological collaborative opportunities, and (3) top executive characteristics affect their assessments regarding the attractiveness of technological collaborative opportunities.

It is widely argued in the cognitive and behavioral literature that individuals are limited in their ability to process information during decision making (e.g., Miller, 1956; March and Simon, 1958). This study supports these contentions and suggests that, even in a very simplified decision situation, executives tend to incorporate only the information they consider most relevant. As a group the participants in this study significantly incorporated only nine of the 17 informational cues they were given into their evaluations; individually they consistently used only 3.7 of the factors.

It is also apparent by the distribution of the significant informational dimensions that no single theoretical lens adequately represents the issues top executives consider relevant when they evaluate collaborative opportunities. According to the results some informational dimensions are more important to top executives than are others. The three informational cues that were the most strongly related to the assessment of the opportunities were the 'significance of the technology to the current strategy' (H1a), the 'compatibility of management styles between the firm and partner' (H1d), and the 'potential for decreasing development risk' (H4a). These results suggest that top executives are aware of and very sensitive to three extremely different informational cues during the evaluations. It is encouraging to see that executives place a strong emphasis on whether the technology is relevant to the firm's strategy and are wary of cooperation at exceptionally high levels of relevance. Given the lack of sensitivity in the past to the differences in management styles of cooperative partners and the negative consequences resulting from that insensitivity (as reported by the public press: e.g., Levine and Byrne, 1986; Sherman, 1992), the emphasis placed on this information cue is also noteworthy. It may well be that the high failure rate of collaboration in the past has made top executives sensitive to the challenges associated with implementing technological collaboration efforts (Dodgson, 1993: Hagedoorn and Schakenraad, 1992). Additionally, the popular press has consistently related collaboration efforts to the desire by firms to decrease their development risk (e.g., Farr, 1990). The results of this study support these contentions.

Three more informational dimensions were used extensively in the evaluations: the 'level of asset-specific investment required' (H2b), the 'total expected cost for development' (H4b), and 'increased exposure to related markets' (H4d). The first two findings suggest a sensitivity by the executives to development costs. The negative relationship between total expected cost and the attractiveness of a technological collaborative opportunity appear to support Kahneman and Lovallo's (1993) arguments regarding evaluations of risky projects by executives. They suggest that in these situations executives will neglect the possibilities of pooling risks and exhibit risk aversion. They argued that, as the size of the loss (i.e., cost of the project) increases, executives can be expected to experience loss aversion which causes them to favor the status quo over any alternative. Other dimensions that were considered by executives in their evaluations were the 'life cycle phase of the technology' (H1c), 'information availability relative to the partner' (H2c), and the 'favorability of the potential partner's cooperative history' (H2d). It should be noted that a wide spectrum of considerations were represented by the nine dimensions that significantly contributed to evaluations of technological collaborative opportunities.

A consideration of the informational dimensions not incorporated into the executives' decision models is also informative. In aggregate, top executives in this sample did not significantly consider information associated with existing skill capabilities, learning, competency building, imitability, or substitutability (H1b, H3a, H3b, H3c, H3d, H3e). These results suggest that executives were not sensitive to the factors that represented the firm's current or future technological skill capabilities. They also did not incorporate information related to the 'number of potential partners' (H2a) or the 'contingency of cost commitments to outcomes' (H4c).

Not only do the executives in this study appear limited in their ability to process pertinent information, but this study also suggests that their own personal experiences affect the decisions they are asked to make on behalf of the organization. CEOs were more critical evaluators than were executives lower down in the organization. Executives with engineering/R&D and marketing functional experiences had more favorable outlooks than those with accounting and finance backgrounds. In addition, executives with a longer industry tenure appeared to weight the information differently from those with a short industry tenure.

It is important to provide a note of caution regarding the study's findings before discussing its implications. This is an exploratory study based on a policy-capturing procedure that uses created scenarios, not evaluations of actual technological collaborative opportunities. This methodology controls the number and wording of information cues executives are provided. To the extent that relevant factors were not included or wording was perceived as ambiguous, these results may be misleading. However, Schwenk (1995) has argued that the use of research methods that allow the direct observation of decision making and control of potential confounding variables is necessary for research on strategic decision making to progress. Policy capturing, as a methodology, allows for the simplification and control of an otherwise very abstract and complex decision area in a way that allows statistical evaluation of the weightings of specific information and a measure of the mental or cognitive models used by the executives making the decisions.

A grounded theoretical approach based on intensive fieldwork could have been used to investigate these same research questions. This type of work could have contributed a richness not possible in a controlled experiment and helped to establish the validity and reliability of the criteria used in this study. The authors do not propose the use of experimental designs as a substitute for field research. Rather, we join Schwenk (1982) in advocating the simultaneous use of experimental methods and field research in a complementary fashion and are hopeful that the findings of this study will provide direction for studies in the field.

TOWARD A NEW INTEGRATED THEORY

As noted in the discussion, no one rational-choice lens proposed in strategy captures the essence of what top executives look at when asked to evaluate technological collaborative opportunities. However, examining the factors that were used by executives in this policy-capturing study can move the field toward an integrated behavioral theory of the attributes top executives use in assessing such opportunities (Figure 1). The nine criteria that executives used can be categorized according to (1) firm attributes, (2) partner attributes, (3) technology attributes and (4) relationship attributes. These nine dimensions alone account for 30.3 percent of the variance over and above the control variables. Executives were interested in the significance of the technology for the firm's strategy, the asset-specific investments required by the firm, and the firm's increased exposure to related markets. The primary concern regarding the partner was its cooperative history. The technological characteristics that were of concern to top executives were the phase of the technological life cycle and the expected cost to develop this technology. Not only were executives concerned about key firm, partner, and technology characteristics, but they were also concerned about issues related to the relationship itself: the compatibility of management styles, information availability relative to the partner, and the potential to decrease development risk. This reorganization of the significant factors in this study from one of critical attributes associated with academic content theories to a structure familiar to business executives has implications for both research and practice.

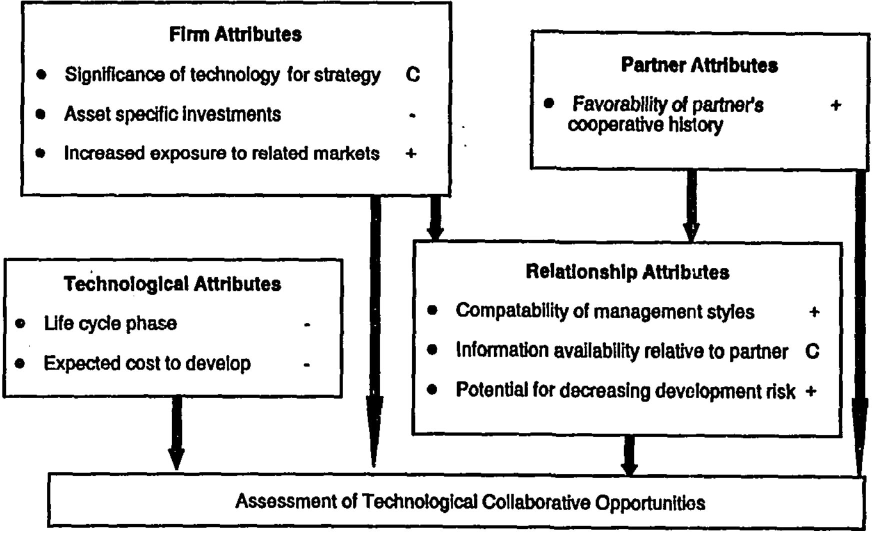

Figure 1. Towards an integrated behavioral theory of the factors executives use in assessing technological collaborative opportunities

IMPLICATIONS AND FUTURE DIRECTIONS FOR RESEARCH

The integrated behavioral theory suggested here is less focused than the theories that have been incorporated into it and more comprehensive in its explanation of what executives consider when asked to make these types of evaluations. Moreover, one could argue that it is closer to the cognitive or mental representations executives actually use in decisions of this nature. Fieldwork could be conducted to evaluate this supposition and to seek additional attributes that might fall within the four categories suggested in the proposed integrated theory. Cognitive mapping techniques could be applied to interviews with top executives currently involved in evaluations of technological collaborative opportunities (Huff, 1990). Other qualitative methods of inquiry could be used both to test and to build theory regarding individual and organizational decision content and process as it relates to technological collaborative relationships (e.g., Glaser and Strauss, 1967; Yin, 1989). Areas that would be particularly fruitful for theory building would be research regarding functional and organizational knowledge structures or dominant logics (Lyles and Schwenk, 1992; Prahalad and Bettis, 1986), organizational learning and knowledge transfer (Fiol and Lyles, 1985), and organizational efforts to protect core technological capabilities from assimilation by partnering firms. Theoretical arguments developed in any of these areas then need to be tested empirically using multiple methods.

This research effort focused primarily on the application of rational-choice perspectives found in the strategy literature, although some consideration was given to the often unconscious executive effects associated with executive level, functional experience, and industry tenure (i.e., cognitive heuristics and biases). More research should be conducted to understand better how executive characteristics influence the evaluation of technological collaborative opportunities. Studies should also be conducted that evaluate the effects of executive focus on collaborative success and whether successful collaboration is enhanced by decisions that are based upon a large number of factors rather than only a few.

Research is also needed to evaluate the international implications of the study's findings. Not only may evaluations of technological collaborative opportunities be affected by individual differences, they may also be affected by differences in company, national, and ethical predispositions or cultures. Companies that have traditionally competed internationally using a multidomestic strategy based on decentralization and market autonomy have developed very different structures, processes, systems, and cultures than companies that have traditionally competed using a global strategy based on centralization and economies of scale (Bartlett and Ghoshal, 1989). Executives from firms whose administrative heritage is that of a multidomestic may focus on very different dimensions than executives from a firm with a global administrative heritage. Likewise, the use of information in evaluations of cooperative efforts may differ according to the power distance, masculinity, uncertainty avoidance, and temporal orientations of executives based on their national and ethnic backgrounds (Hofstede, 1993). Finally, executives may process information differently due to national differences in public policies and the level of economic development (Nelson and Rosenberg, 1993).

Finally, this study has only examined the factors executives use to evaluate various technological collaborative opportunities. Collaboration, however, is but one means of obtaining technological know-how. Alternative modes include licensing, acquisition, and internal development (Ford, 1988; Roberts and Mizouchi, 1989). Studies should also be conducted examining the choice between the various methods of technological acquisition using an integrated theoretical perspective. Insights regarding the primary factors that trigger the choice between these modes would be a valuable contribution to both theory and practice.

IMPLICATIONS FOR PRACTICE

The results of this study suggest that a cross-section of executives asked to evaluate technological collaborative opportunities focused on the decision factors depicted in Figure 1. Given that many firms now compete through their ability to collaborate effectively, an understanding of these factors may assist the practitioner. Top executives involved in this type of decision can use these results to compare their decision criteria with that of the sample of executives in this study. If they have not recognized the relevance of certain types of information, the theoretical arguments outlined in this article may help executives shorten the collaborative search process by eliminating inappropriate (e.g., risky, different management style) partners early in the process. By understanding how others evaluate collaborative opportunities, executives may also be better able to predict the response of potential partners to their overtures for shared development. In addition, executives seeking to position their firms as attractive partners have empirical data (reported here) regarding what makes a firm more or less attractive.

The fact that top executives in this study did not emphasize the criteria associated with current technological skill capability, the potential to learn from the collaborative relationship, and the imitability and substitutability of technological skills, suggests that they do not recognize the value associated with resource capabilities. According to Hamel (1991) the intent to learn should be a primary concern for a company wanting to develop and strengthen internal distinct competencies that can provide a competitive advantage. Top executives should ask themselves if they adequately consider the value of their firm's internal resources (e.g., skills, capacity to learn, tacit knowledge) and the potential for resource development when evaluating technological collaborative opportunities. They should do an assessment of their firm's current skill capabilities and see what skills might be lacking before they begin looking for cooperative partners. They should also evaluate their capacity to 'learn' from such a relationship. Executives may find that their organization's capacity to learn is limited because personnel are not encouraged or taught to transmit the knowledge they gain to others in their organization (i.e., it does not become organizational knowledge).

Assuming that a careful evaluation of multiple criteria is important to a quality evaluation of technological collaborative opportunities, companies need to know how individual decision-making limitations can be overcome. The limitations of individuals as decision makers are most often addressed by using groups to make important decisions. Significant academic research has looked at the effect of composition of top management teams on organizational decisions. Generally this research has shown that diversity within the team in turbulent environments improves the quality of decisions (e.g., Bantel and Jackson, 1989). If a diverse perspective is not naturally part of the group, research has also shown that better decisions can be made by encouraging disagreement (i.e., creating diversity of opinion) in a structured way (Cosier and Schwenk, 1990). Firms may also compensate for limitations of individual cognitive capabilities by creating decision support systems that help individual executives incorporate and weight informational dimensions during decision making (Silver, 1991). The recent advances in information technology have made this type of support system fairly accessible and user friendly (Benbasat and Nault, 1990). Two simple suggestions could prove useful to executives involved in evaluating technological collaborative opportunities: (1) they can document their firm's evaluation process and the types of information they consider relevant; and (2) they can initiate benchmarking efforts to compare 'best practices' of other firms with experience in cooperative relationships.

CONJECTURES AND SPECULATIONS

While policy capturing allows us to quantify and weight the overall use of information, it does not provide information on the specific thought processes and feedback loops the executives have used. Once an executive has established an initial understanding of the informational dimensions available for consideration, he or she may use any number of methods to proceed. Three examples should suffice: (1) executives may look at the information from top to bottom as it has been ordered and make an evaluation when they reach the bottom of the page; (2) they may determine that only three or four informational cues are relevant to the decision and then ignore information unrelated to these key dimensions; or (3) they may evaluate the opportunity along a few dimensions and, only when the situation looks favorable, begin to evaluate another set of informational cues. Both theory and practice would be advanced by a more complete understanding of the process by which decision makers evaluate information.

Although the policy-capturing exercise conducted and reported here cannot provide an explanation for why the top executives involved in this study did not attend to the informational dimensions related to current and future skill capabilities, a few conjectures and speculations concerning this lack of consideration may push the field forward in both theory and practice. With this purpose in mind, five potential explanations are put forth. First, top executives may be detached from skill accumulation and transfer, which typically takes place further down in the organization. Because top executives are required to focus on environmental scanning, boundary spanning, and long-term strategic direction, they may be less knowledgeable regarding the firm's internal technological skills and capabilities. Secondly, while top executives may recognize that technological knowledge and learning are important, they may not understand how to manage or improve organizational learning and so prefer to focus on aspects of the decision they can more easily predict and quantify. A third potential explanation is that, because technological advancement is so rapid, top executives are more concerned with developing the next product or platform and staying ahead of competitors than they are with skill and knowledge acquisition or loss. It may be, however, that the study's findings are representative of only the first step in the evaluation process. The evaluation process may be a two-step process in which strategic and financial factors dominate the initial screening and skill capabilities and learning only become a consideration during final selection. Finally, academic and practitioner communities have suggested that U.S. executives are short-term oriented (e.g., Davis, 1992; Erickson and Jacobson, 1992; Ford, 1988; Lohr, 1992). The study's results may be due to the fact that the top executives in this sample are indeed short-term oriented and insensitive to the need to develop and internalize technological skills and core competencies (Prahalad and Hamel, 1990).

CONCLUSION

Technology-driven companies are faced with a changing competitive landscape characterized by rising costs of development, rapid technological diffusion, compression of product life cycles, product and market uncertainties, and globalization. Those firms that respond to this dynamic environment by establishing technological collaborative relationships cannot afford to discount the importance of a cautious and deliberate assessment of the cooperative opportunities available. As industries are transformed by networks of cooperative alliances, the assessment process for technological collaboration will increase in its importance. This exploratory study has sought to bring to the forefront factors that should be important to executives as they make these types of evaluations, and it proposes a tentative model of the factors that top executives actually consider. The study therefore serves as both an integration of theoretical lenses and a point of departure for a much needed understanding of the factors important to selection of technological collaborative relationships.

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Appendix: Evaluation report for technology and potential partner firm AF

Technology and partner characteristics	Low 1	Mod. low 2	Average 3	Mod. high 4	High 5
1. Significance of the technology for your company's strategy	[]	[]	[x]	[]	[]
2. Life cycle phase of the technology (e.g. Low=Introduction, High=Decline)	[]	[x]	[]	[]	[]
3. Existing skill capability your company has to develop this technology	[]	[x]	[]	[]	[]
4. Importance of 'learning by doing' associated with the technology	[]	[x]	[]	[]	[]
5. Total expected cost for developing the technology	[]	[x]	[]	[]	[]
6. Number of other potential partners with similar joint development capabilities	[x]	[]	[]	[]	[]
7. Extent of asset-specific investments required (i.e., capital investments that cannot be used for other purposes)	[]	[x]	[]	[]	[]
8. Favorability of potential partner's cooperative history	[x]	[]	[]	[]	[]
9. Potential for broad corporate application of the technology	[]	[x]	[]	[]	[]
10. Extent to which the technology can be patent protected	[x]	[]	[]	[]	[]
11. Potential for decreasing development risk through the cooperative relationship	[]	[]	[]	[]	[x]
12. Extent to which your company has information regarding this technology, relative to the potential partner	[]	[]	[]	[]	[x]
13. Your company's potential to learn from the cooperative relationship	[]	[]	[]	[]	[x]
14. Extent of technological substitutes currently available	[x]	[]	[]	[]	[]
15. Potential for increased exposure to related market opportunities	[]	[]	[]	[x]	[]
16. Compatibility of operating and management styles between your company and partner	[]	[]	[]	[]	[x]
17. Extent to which incremental cost commitments can be made contingent on favorable technological outcomes	[]	[]	[]	[]	[x]

Based upon the information provided above, and your experience and knowledge, please rate the attractiveness of this situation for a cooperative/partnering relationship. Place an X in the appropriate space.

Very unattractive 1 2 3 4 5 6 7 Very attractive

What is the probability that you would recommend this cooperative relationship? Place an X in the appropriate space.

Low probability 1 2 3 4 5 6 7 High probability