1-1-2003

Complementary Resources and the Exploitation of Technological Innovations

David R. King
Marquette University

Jeffrey G. Covin
Indiana University

W. Harv Hegarty
Indiana University

Published version. *Journal of Management,* Vol. 29, No. 4 (2003): 589-606. DOI.
David R. King was affiliated with the Air Force Pentagon at the time of publication.

Pergamon

JOURNAL OF MANAGEMENT

Journal of Management 2003 29(4) 589–606

Complementary Resources and the Exploitation of Technological Innovations☆

David R. King*
Air Force Pentagon, SAF/AQP Room 11-105, 1500 Wilson Blvd., Arlington, VA 22209, USA

Jeffrey G. Covin
Department of Management, Kelley School of Business, Indiana University, Room 666D, 1309 E. Tenth Street, Bloomington, IN 47405-1701, USA

W. Harvey Hegarty
Department of Management, Kelley School of Business, Indiana University, Room 650G, 1309 E. Tenth Street, Bloomington, IN 47405-1701, USA

Received 1 October 2001; received in revised form 15 July 2002; accepted 25 September 2002

Technological innovation often results when the resources of a small firm are combined with those of a large one. This is because small and large firms characteristically possess complementary resources whose combination can facilitate innovation success. The possession of complementary innovation-producing resources by small and large firms helps explain patterns of interaction among firms in dynamic, technology-based industries. Propositions are developed that outline how typical resources of small and large firms can be used to explain industry-level phenomena surrounding technological change.
Published by Elsevier Science Inc.

The pursuit of innovation is often vital to achieving competitive advantage in dynamic, technology-based industries (Eisenhardt & Martin, 2000; Lynn, Morone & Paulson, 1996; Porter, 1990, 1998). Goodman and Lawless (1994) suggest that firms can pursue innovation using internal or external modes. A third, collaborative mode of innovation is also commonly employed (Kor & Mahoney, 2000). Firms will sometimes collaborate in the pursuit of

☆ *Disclaimer*: The views expressed in this article are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the US government.

* Corresponding author. Tel.: +1-703-588-7170; fax: +1-815-550-4984.
E-mail addresses: David.King@pentagon.af.mil (D.R. King), covin@indiana.edu (J.G. Covin), hegarty@indiana.edu (W.H. Hegarty).

0149-2063/03/$ – see front matter. Published by Elsevier Science Inc.
doi:10.1016/S0149-2063(03)00026-6

innovation when the individual firms do not possess all of the necessary innovation-producing resources. Resource complementarities of the individual firms are of particular importance to innovation success when collaboration is the chosen innovation mode (Harrison, Hitt, Hoskisson & Ireland, 2001).

Firm size may be a critical determinant in choosing an innovation mode. When two or more firms are involved, Williamson (1975) hypothesized that an efficient approach to innovation is having the initial product or technology development performed by small firms, then having successful developments acquired by large firms for subsequent production and marketing. However, Davidson (1991) criticized this external innovation approach involving the acquisition of small firms by large firms because, though large firms can acquire rapidly growing firms to increase their growth rate, the resulting firms are unlikely to grow as fast as smaller, innovative firms that remain independent. Davidson's (1991) observations notwithstanding, it is plausible that small and large firms possess complementary resources that are uniquely suited to facilitating the innovation process. Still, how the resources of small and large firms are combined in collaborative innovation within industries is a matter that has not received extensive treatment in the literature.

In this paper, our goal is to develop a framework and related propositions that outline how the unique resources of small and large firms can be used to explain firm behavior within the industry-level technological change process. We build on prior insights from several research streams including: alliances (e.g., Eisenhardt & Schoonhoven, 1996; Parkhe, 1993), control systems (e.g., Hitt, Hoskisson, Ireland & Harrison, 1991; Hitt, Hoskisson, Johnson & Moesel, 1996; Hoskisson & Johnson, 1992), dynamic capabilities (e.g., Eisenhardt & Martin, 2000), entrepreneurship (e.g., Covin, Prescott & Slevin, 1990; Schumpeter, 1934), innovation (e.g., Anderson & Tushman, 1990; Utterback & Afuah, 1995), mergers and acquisitions (e.g., Capron, 1999; Gerpott, 1995; Pablo, 1994), and real options reasoning (e.g., McGrath, 1999; McGrath & MacMillan, 2000). We focus on exploring the independent roles of small and large firms within the industry-level technological change process (Propositions 1 through 3) as well as on the reasons why small and large firms often collaborate (Propositions 4a and 4b), or, in the case of small firms, fail (Proposition 4c) at particular stages of this process.

A three-stage process of industry-level technological change (Anderson & Tushman, 1990; Utterback & Afuah, 1995) frames our propositions for how small and large firms independently and collaboratively contribute to technological innovation. Briefly, the cycle begins with a technological discontinuity, or a significant, technology-based change in how market needs are met. The second stage begins after a dominant design emerges, or when product features do not vary and the design achieves a large market share (Utterback & Afuah, 1995). The emergence of a dominant design represents a particularly significant point in an industry's life cycle. It is at this point that small and large firms pursue collaboration to further develop and appropriate rents from technological innovations. The third stage of industry-level technological change represents a period of incremental change focused on marginal improvement in the efficiency or performance of the technology. The technology life cycle begins anew with the introduction of another technological discontinuity. Next, we briefly review the literature on the relationship between firm size and innovation.

Firm Size and Innovation

Innovation is defined as the invention and commercialization of new products or services based on the application of technological and/or market knowledge (Hitt & Ireland, 2000). The capability for innovation is scarce and may never be available in abundance (Berry & Taggart, 1994). This capability is also valuable, and competitive advantage is commonly achieved by firms proficient at innovation. As Chen and Hambrick (1995: 453) note: "a basic understanding of how organizational size influences competitive behavior is of paramount importance." Given that technological innovation is key to competitive behavior in many industries, it is not surprising that the effects of firm size on the innovation process are generally viewed as worthy of consideration (Hamilton, 1985).

Still, the impact of firm size on innovation is poorly understood (Acs & Audretsch, 1988; Bittlingmayer, 1996) and, consequently, inconsistently depicted in the literature. This inconsistency is reflected, for example, in Schumpeter's seminal works (1934, 1942) that identify the small entrepreneur (1934) and then big business (1942) as the major source of innovation. As the following discussion shows, conflict between viewing small or large firms as the primary source of innovation still exists. Our review is not intended to be exhaustive. Rather, it is meant to show the variety of positions regarding firm size and innovation, and to demonstrate a need for research clarifying this relationship.

A linear relationship between firm size and innovation is suggested in much of the literature, with small firms presented as having an innovation advantage by some authors (e.g., Freeman & Soete, 1997; Gilder, 1988; Kim, 1988; Rodgers, 1990; Rosen, 1991; Stringer, 2000), and large firms presented as having an innovation advantage by others (e.g., Cohen & Klepper, 1992; Ferguson, 1988; Nelson & Winter, 1978; Schnaars, 1994; Yearly, 1988). The possibility of a non-linear relationship between firm size and technological innovation rate is also reflected in the literature. For example, several authors have suggested that large firm size confers an innovation advantage, however above a certain size threshold this advantage disappears (Baldwin & Scott, 1987; Kamien & Schwartz, 1982; Scherer, 1980). The relationship between firm size and innovation rate has also been described as U-shaped, with small and large firms being more innovative than medium-size firms (Pavitt, Robson & Townsend, 1987).

Several authors have also noted that firm size has implications for particular stages of the innovation process or for particular types of innovation. For example, Sen and Egelhoff (2000) argue that small firms are better at producing radical innovations, while large firms are better at producing incremental innovations. Scherer (1991) concluded that large firm size often has a positive effect on the development of ideas, but a negative effect on the generation of ideas. Moreover, small firms are considered the dominant source of innovation during the earliest stage of a technology's evolution, with the locus of innovation shifting to larger firms in the transitional and more mature stages (Berry & Taggart, 1994). As a product matures, manufacturing competence often becomes critical to business success as the primary basis of competition characteristically shifts to cost and efficiency (Tushman & Romanelli, 1985). Such competence is most common among large firms that excel at process R&D (Klepper, 1996). Consistent with these points, Abernathy and Utterback (1988) describe small firms as the principal source of product innovations and large firms as the principal source of process innovations. As will be discussed later, organizational control systems theory and research (e.g., Baysinger & Hoskisson, 1989; Goold & Campbell, 1987) and real options reasoning (e.g., McGrath, 1999; McGrath & MacMillan, 2000) may also help explain relationships between firm size and innovation within the stages of technological change.

Of particular importance to the current paper, the firm resources that characteristically vary with firm size can have a significant impact on the technological change process and innovation outcomes. Roberts (1980) described large firms as having innovation-enhancing resource advantages in the areas of, for example, capital, distribution channels, and sales force strength. Meanwhile, small firms possess innovation-enhancing resource advantages in the areas of, for example, technological flexibility and entrepreneurial commitment (Roberts, 1980). Rothwell and Dodgson (1991) categorize the innovative advantages of large firms as "material-based" and small firms as "behavioral." We further develop insights on differences in size-related innovative resources by suggesting that large and small firms characteristically possess complementary innovation-enhancing resources. These resource complementarities can invite collaboration between firms for innovation exploitation purposes. How commonly firms rely on the resources of others to achieve competitive advantage is an issue deserving additional research attention (Dyer & Singh, 1998). Nonetheless, it appears that large and small firms often recognize complementary innovation resources in each other. This recognition can help explain Acs and Audretsch's (1988) finding that industries with large firms are more innovative, but that the innovations come from small firms.

Complementary Resources and the Pursuit of Innovation

The challenges of large and small firms as producers of innovation are often vastly different. Comparing the innovation-related characteristics of large and small firms reveals that in many cases an innovative disadvantage of large firms is an innovative advantage for small firms, and vice versa, which can make collaboration between two firms of different size desirable for both parties. For example, small firms are often particularly responsive to market changes (Rothwell & Dodgson, 1991), which can facilitate the ability of any potential large firm partner to identify emerging markets and technologies that might otherwise threaten the large firm's existing business operations. Additionally, small companies are more agile than larger companies. As such, collaboration between small and large firms can make the larger firm less susceptible to an environmental mismatch and subsequent organizational decline (Ahuja & Lampert, 2001; Bower & Christensen, 1993). Finally, small firms tend to have entrepreneurial and organic management styles, characterized by risk acceptance, adaptability, flexibility, and open communications (Covin, Prescott & Slevin, 1990). Such qualities can help balance the effects of the bureaucratic and financial controls typical of large firms and enable large firms that collaborate with smaller ones to better recognize and exploit innovative opportunities.

Similarly, large firms can often compensate for the innovation-related disadvantages of small firms based on, for example, their reputation and greater access to resources. Smaller firms are often eager to cooperate in the pursuit of innovation with larger, established companies because of name recognition and reputation spillover effects (Teece, 1986). Large firms also commonly possess greater manufacturing, marketing, sales, distribution, financial, and/or managerial resources that small firms may need as part of their efforts to exploit innovations (Alvarez & Barney, 2001). The following sections outline how the resources of small and large firms may be used to predict their independent and collaborative actions during the process of industry technological evolution.

Technological Discontinuities and the Behavior of Small and Large Firms

After a technological discontinuity, technology is largely experimental and its applications are often unclear. The new technology frequently does not work well and early designs serve as market experiments. For example, the first personal computer, the Altair 8800, by Microinstrumentation & Telemetry Systems (MITS), was introduced in 1975 as a kit of blinking lights that could be assembled and crudely programmed with paper punch tape (Carlton, 1998). As new technology matures it begins to displace the technology used in existing markets, such as when electronic calculators began to replace mechanical calculators in the 1970s.

Large companies often surrender emerging markets to smaller firms as a consequence of their characteristic responses to technological change (Christensen, 1997). In particular, large, established firms typically improve existing, older technology in response to encroaching new technologies (Anderson & Tushman, 1990) and delay investment in new technologies until their technical or economic viability is better assured (Courtney, Kirkland & Viguerie, 1997). Technological discontinuities can render a large firm's technology-based resources obsolete, but leave non-technology-based resources in marketing and manufacturing unchanged. Lieberman and Montgomery (1998) suggest that firms with relative strengths in marketing and manufacturing, typical of larger firms, often enter markets later when technological uncertainty is resolved. Real options reasoning (McGrath, 1999) is key to understanding why large firms may choose to delay investments in new technology. Assuming that large firms have options to adopt new technology when uncertainty decreases, it is rational for large firms to cede risky market experiments to small firms as a means of coping with uncertainty.

Quite often, successful innovation requires allocating significant resources away from clear current needs to ambiguous future-oriented needs. This resource allocation uncertainty can result in a dilemma. On one hand, the resources invested in the pursuit of innovation do not always lead to new product or service success. One estimate is that 46 percent of R&D goes toward products that ultimately fail (Hudson, 1994). On the other hand, firms that ignore the pressure to innovate risk technological obsolescence, loss of market share, and potential financial failure. The result is that most firms, if they are to survive, must stay on an innovation treadmill (Freeman & Soete, 1997; Porter, 1998).

Delays by large firms in pursuing new technology create opportunities for entrepreneurs and are a contributing factor to Schumpeter's (1934: 225–227) observation that small firms appear in a "swarm-like" fashion to compete side-by-side with existing, large firms. Smaller firms are less likely to be dissuaded by the uncertain growth prospects that accompany many technological innovations (Christensen & Bower, 1996). Moreover, smaller firms are more likely to rely on strategic controls—long-term and strategically relevant criteria used to evaluate firm performance (Hitt, Ireland & Hoskisson, 1999)—that can facilitate the generation of technological innovations (Hitt et al., 1996; Hoskisson & Johnson, 1992). Succinctly, the following relationships are proposed:

Proposition 1a: Large firms, in comparison to small firms, are more likely to focus on existing technology and delay investment in new technology following a technological discontinuity.

Proposition 1b: Small firms, in comparison to large firms, are more likely to develop new technology following a technological discontinuity.

For a variety of reasons, small firms may be more likely than large ones to embrace externally originating innovations that represent or follow technological discontinuities. Research by Christensen and Bower (1996) suggests that the majority of technological discontinuities may originate in large firms. However, Christensen and Bower (1996) also note that large firms often pass on developing new technologies that threaten current technologies or whose value is uncertain. Cooper and Schendel (1976) found that small firms are typically responsible for developing and championing the technological innovations that eventually become industry standards. An example of a (formerly) small firm that championed an innovation developed by a large firm is Apple Computer. In particular, Apple Computer developed the graphical interface for its Macintosh computer based on an invention of Xerox Corporation's Palo Alto Research Center (Carlton, 1998).

Small firms typically spot emerging trends and product opportunities before large firms (Schnaars, 1994), and the former may have an advantage in accessing external technology from government organizations, public or private universities, or other organizations that perform research (Audretsch, 1999; Freeman & Soete, 1997). The advantage of small firms in exploiting external R&D can be viewed as the result of personnel mobility where people joining or founding new firms help to diffuse technology (Goodman & Lawless, 1994; Hitt, Ireland & Hoskisson, 1999). For example, small firms receive more technology-based spillovers from universities than do large firms (Acs, Audretsch & Feldman, 1994; Audretsch, Weigand & Weigand, 2000). Stanford University provides multiple examples of firms founded out of a university, including: Cisco Systems, Hewlett-Packard, Logitech, Silicon Graphics, Sun Microsystems, and Yahoo (Hamilton & Himmelstein, 1997). Another source of technology-based spillovers is founders of entrepreneurial firms leaving established technology intensive firms (Porter, 1990). Large firms may exhibit agency problems where employees with new ideas have incentives to externally appropriate the value of their knowledge (Williamson, 1975). In other words, an employee may obtain greater financial rewards by joining or founding an entrepreneurial firm than by remaining an employee of a large firm. In summary, rapid change in technology generates opportunities for firms to appropriate external technology, and small firms may be better positioned and/or more inclined than large firms to pursue these opportunities. Therefore, the following relationship is proposed:

Proposition 2: Small firms, in comparison to large firms, are more likely to incorporate external technology following a technological discontinuity.

Advances in technology often take place within a given industry, and the introduction of new technologies does not, by definition, create new industries. The shift from mechanical to electric typewriters, for example, did not significantly alter the composition of the typewriter industry (Cooper & Smith, 1992). Industries are created when a new group of firms emerge offering similar products to satisfy a latent market. Nonetheless, new technology can also lead to the creation of new industries.

Small firms, in comparison to large firms, will be more likely to introduce new technologies that create new industries because small firms will be more likely to pursue technological innovations that have limited or uncertain initial appeal in their product applications (Christensen & Bower, 1996; Cooper & Schendel, 1976). The products incorporating these novel technologies are, in essence, market experiments that, if successful, will induce the entry of other firms into the newly recognized and validated product-market arena, thus precipitating the emergence of a new industry. Of key importance here, large firms will often overlook novel technologies that appeal to small firms because the former will need the promise of greater returns to justify the pursuit of small markets or market experiments (Christensen, 1997). By the time the new technology is validated in the eyes of large firms that may or may not have had an early interest in the technology, a new industry will often have formed around the emerging technology championed by the small firm (Zahra, Nash & Bickford, 1995). The aforementioned example of the personal computer industry following the technological lead of MITS is consistent with this argument. In short, the following relationship is proposed:

Proposition 3: Small firms, in comparison to large firms, are more likely to develop new technologies that result in the creation of new industries.

Dominant Design and Interfirm Collaboration

The preceding propositions recognize the important role small firms play in advancing industry-level technological innovation. However, as small, entrepreneurial firms grow they often become aware of resource shortcomings that limit their ability to appropriate rents from the technological innovations and associated market niches they have embraced. This shift represents a significant point in an industry's life cycle where small firms begin to seek out potential collaborators with the complementary resources they need. At the same time, technology uncertainty is reduced and large firms seek partners in new technological arenas increasingly recognized as viable. This is most likely to occur as the technological innovation "matures" and a small firm finds itself with the dominant design.

Utterback and Abernathty (1975) identified the emergence of a dominant design, or the broad acceptance of certain "standard" technological or product attributes, as a key event in the evolution of an industry. Further, Teece (2000) identified the emergence of a dominant design as a signal of rapid growth where complementary resources become critical to innovation success. As competition coalesces around a dominant design, access to resources traditionally associated with large firms (e.g., distribution channels, specialized manufacturing, and marketing) becomes critical to firm performance (Teece, 1986, 2000). Large firms by virtue of their size, scope, and reputation may advance a dominant design simply by choosing to adopt a particular technology (Teece, 2000). For example, when IBM introduced its personal computer (PC) in 1981, it helped set the Intel microprocessor and Microsoft DOS standard (Lawless & Anderson, 1996).

A dominant design also brings new competitive pressures as the focus of competition shifts. Small firms have been competing for acceptance of their technology and large firms have either focused on older technology or waited for decreased technological uncertainty. The result is an increase in the need to collaborate for innovation exploitation purposes. Small firms are more willing to collaborate with larger firms that can quickly provide non-technology-based resources they need to adequately serve a market. At the same time, after the emergence of a dominant design, and consistent with real options reasoning (McGrath, 1999), large firms are more willing to invest in a proven technology and market. Additionally, the large, established companies are more likely to be competent at the process innovation now required to lower costs (Utterback & Afuah, 1995). The significant factor is that the relative needs of small and large firms now complement each other, or exhibit a balanced asymmetry (i.e., where the resource strengths of one firm are the resource deficiencies of another) such that collaboration is viewed as mutually desirable.

Research on control systems also explains why technological progress is often contingent upon small and large firm collaborations. As a generalization, small firms are likely to emphasize strategic controls designed to assess and guide firm-level strategic actions (see, for example, Goold & Campbell, 1987), whereas large firms are likely to emphasize bureaucratic and financial controls designed to assess and guide individual behaviors, organizational processes, and financial outcomes (see, for example, Baysinger & Hoskisson, 1989). Strategic controls are commonly associated with increased R&D spending and more frequent product introductions (Hitt et al., 1996; Hoskisson & Johnson, 1992). Financial controls are commonly associated with risk aversion, decreased R&D spending, and a focus on efficiency (Hitt et al., 1991; Loescher, 1984). Importantly, industry-level technological advancement requires both types of controls. Strategic controls can induce the technological innovations most commonly associated with the first stage of the technological change process, and financial controls can enable firms to more efficiently employ and/or marginally improve those innovations during the third stage of technological change (Mezias & Glynn, 1993). This is because innovation is both path- and time-dependent, and the likelihood of a technological discontinuity is lowest immediately after one has occurred. Thus, small and large firms are both likely to excel at particular stages of the industry-level technological change process based, in part, on the control systems they are likely to embrace. In short, control systems theory and research help explain small and large firm innovative behavior, and provide the general motivation behind their collaborative efforts to appropriate rents from technological innovations.

The more specific motivations for collaboration between large and small firms following the emergence of a dominant design are many. Collaboration with small firms provides large firms faster entry into markets and faster access to technology resources than would be possible through internal development (Bittlingmayer, 1996; Gerpott, 1995; Hadegdoorn, 1993; Kogut, 1991). Additionally, large firms may view collaboration with small firms that have technologies of known desirability as a means to protect established brand equity and avoid implicitly endorsing new technologies of questionable value (Lieberman & Montgomery, 1998). Collaboration with large firms offers small firms access to needed managerial, financial, and marketing resources (MacDonald, 1985). Small firms may also view collaboration with large firms as signaling enhanced legitimacy of their product (Baum & Oliver, 1991; Wernerfelt, 1988), or offering access to market power (Hadegdoorn, 1993). Although collaborative activities go beyond alliances and acquisition (e.g., licensing), we limit our discussion of small firm–large firm collaboration to these two options.

Alliances, or cooperative arrangements between two or more organizations for specific strategic ends, are normally designed to supplement the weak functions of one's own organization (e.g., technology, manufacturing, distribution, or marketing) through leveraging the strong functions of collaborators. Complementary resources between firms will often motivate vertical alliances, where firm operations emphasize different stages of the value chain and, as such, exhibit resource profile differences (e.g., to have its innovative output efficiently produced, an R&D design firm forms an alliance with a large manufacturer of electronic equipment). The presence of complementary resources in prospective alliance partners may also partially motivate horizontal alliances, where firm operations emphasize the same stage of the value chain and exhibit resource profile similarities (e.g., two computer software companies form an alliance to develop a new operating system). However, in the case of horizontal alliances, factors other than resource complementarity are also likely to come into play as strong motivators of the collaboration. For example, firms may form horizontal alliances thereby combining their resources to reach some minimum efficient scale, or to reap economies of scale. Moreover, if a positive correlation exists between market share and firm profitability in the industry in which two firms at the same value chain stage operate, then alliances may be more likely regardless of how similar the firms' resource profiles are. In short, access to complementary resources may be of interest to potential partners in both vertical and horizontal alliances. In the case of vertical alliances, the complementarity of the potential collaborators' resources—that is, how well one collaborator's strength offsets another's weakness—will likely be of obvious and, perhaps, principal interest to the firms. However, in the case of horizontal alliances, finding alliance partners with *needed* resources will be of primary concern to potential collaborators, and these needed resources may augment as much as complement those of collaborators.

Alliances between small and large firms for innovation exploitation purposes are likely to be equity-based, for two reasons. First, financial resources are often part of the complementary resource set provided by large technology-based firms to smaller technology-based firms with whom they enter into alliances. Small firms with promising technologies often need financial resources to further develop those technologies. The ability of these firms to obtain external financing is limited due to information asymmetries that make specialized technology resources valuable, but also difficult to appraise and resell (Zahra, 1996). Large firms with technological competencies similar to those of prospective small firm alliance partners may be well positioned to judge the value of the small firm's technology resources due to the firms' overlapping technological knowledge (Hitt, Harrison & Ireland, 2001). As such, large technology-based firms often provide financial resources to small technology-based firms and in doing so acquire an ownership or equity stake in the smaller firm. Second, a firm needing resources from another may want its alliance partner to have a vested interest to reduce agency costs. When a large firm takes an equity position in a smaller firm, for example, it immediately acquires a vested interest in the welfare of the smaller firm, which will likely suit the (other) small firm shareholders. Moreover, since the resources small technology-based firms need from their larger firm alliance partners are likely to go beyond financial resources, equity-based alliances that align firm interests may be sought to promote the full sharing of needed resources between the alliance partners. Still, there is nothing about the resource needs of small and large firm alliance partners that demands their collaborations will be equity-based.

Alliances—whether vertical, horizontal, equity-based, or non-equity-based—can offer both large and small firms a way to reduce costs and provide access to relevant non-resident expertise (Sharma, 1999). Under conditions of globalization and rapid technological advancement, alliances represent an increasingly important strategy for firms (Eisenhardt & Schoonhoven, 1996; Parkhe, 1993), and a growing number of alliances are between large and small firms (Alvarez & Barney, 2001). According to Eisenhardt & Schoonhoven (1996), alliances are more likely if the prospective collaborators (1) are in vulnerable strategic positions; (2) both have and need strategically relevant resources; and (3) operate in stabilizing markets. Notably, these three conditions characterize the situation between small firms with valuable technology-based resources and large firms with valuable non-technology-based resources following the emergence of a dominant design. Therefore, the following relationship is proposed:

Proposition 4a: Alliances between small and large firms increase after the emergence of a new dominant design.

If the benefits of collaboration in the pursuit of innovation cannot be achieved through alliances, firms may resort to mergers or acquisitions. Alliances will generally require less strategic and financial commitment to one's collaborative partner than will acquisitions or mergers. Therefore, alliances are often perceived as the least risky of the collaborative options. However, the effective use of alliances may be precluded by, for example, market defects resulting from the existence of intellectual property protection (e.g., patents) or the tacit nature of the information involved (Teece, 1986). Moreover, Teece (1982, 1986) argues that complementary resources that are specialized expose contractual relationships, such as alliances, to hazards where the parties may have to commit irreversible investments that become worthless if the relationship breaks down. When they occur, breakdowns in contractual relationships may require that the transactions be internalized within single firms through mergers or acquisitions (Williamson, 1975). Additionally, acquisitions, relative to alliances, offer greater control over (formerly) external resources (Haspeslagh & Jemison, 1991), as well as faster and more complete access to those resources (Das & Teng, 1998).

As a collaborative option for firms, acquisitions are a well-recognized strategic tool for sustaining or increasing innovative output (Ahuja & Katila, 2001; Stringer, 2000) with large firms often acquiring smaller firms (Pablo, 1994). Acquisition is the collaborative option chosen by many large firms because it can provide, for example, increased speed of entry into new technological and/or product-market domains, lower cost of entry into those domains (than would be likely through internal, organic growth), and exposure to superior resources (e.g., technological competence) that might not be replicable through internal development (Capron, 1999; Lowe & Taylor, 1998; Roberts & Berry, 1985). The complementary resource-based rationale for collaboration between small and large firms for the purposes of exploiting technological innovations remains the same for acquisitions as for alliances. Therefore, the following relationship is proposed:

Proposition 4b: Acquisition activity between small and large firms increases after the emergence of a new dominant design.

Singh (1997) found that increased industry technology complexity corresponds with higher rates of business failure. After the emergence of a dominant design, the failure rate among small firms that incubate new technologies may be particularly high as a function of two factors. First, many of these firms will not be able to build or gain access to the non-technology-based resources needed to fully obtain rents associated with their technological innovations. Second, many of these firms will be pursuing technologies that fall outside the dominant design, and the natural selection process imposed by market forces will cause their demise (Tegarden, Hatfield & Echols, 1999). The impact of natural selection accounts for the observation that the more firms entering a given market, the greater the chances that surviving firms will be highly competent (Utterback & Afuah, 1995).

Contributing to the aforementioned natural selection effects, small firms founded by entrepreneurs with technical expertise often fall victim to myopia concerning changing market conditions and their associated technological implications (Burgelman, Maidique & Wheelwright, 2001). Consequently, technical entrepreneurs frequently persist with their initial product-market offerings despite evidence of the inadvisability of such actions, as suggested by the market's embracing of products based on alternative technology standards. For example, in 1980 there were dozens of companies offering personal computers with unique, platform-dependent hardware and/or software configurations. The great majority of these firms ceased operations when the industry matured and they failed to create new value propositions consistent with the demands of the market for products based on particular technology standards (Lawless & Anderson, 1996). In short, the following relationship is proposed:

Proposition 4c: After the emergence of a new dominant design, small firms, in comparison to large firms, are more likely to persist with competing designs resulting in higher firm failure rates.

Discussion

We have theoretically explored how differences in firm size might explain observed patterns of innovation and associated firm behavior in industries undergoing technological change. In particular, by pulling from several streams of research (e.g., on alliances and acquisitions, control systems, and real options) and relying on established concepts (e.g., dominant design, technological discontinuity), we have extended the dominant existing model of technological innovation (as advanced by, for example, Anderson & Tushman, 1990) to explain how small and large firms commonly contribute and adapt to industry-level technological innovation. The novelty and value added of our paper results from its generation of an integrated set of propositions that explain the independent and joint actions of small and large firms relevant to the technological innovation process. A potential side effect of our relying upon and integrating established theory and concepts is that, individually, some of our ideas may not appear new. However, we believe that, taken as a whole, our observations offer novel insight into how complementary resources among small and large firms facilitate innovation in dynamic, technology-based industries.

Theoretical, Managerial, and Policy Implications

Our collective observations and arguments have several theoretical implications. For example, the emergence of collaborative efforts between firms of various sizes may represent a particularly significant point in an industry's technology life cycle. Such efforts may signal the acceptance of a dominant design as well as the prospect of collaborative gains that increase overall industry attractiveness. Another theoretical implication is that the failure of many large firms to achieve high levels of innovation may be a predictable result. Given the strong linkages that seem to exist between innovation-facilitating attributes and firm size, perhaps it should not be too surprising that even large firms do not often possess a "complete" set of resources that facilitate progress through all stages of the technological innovation process. Moreover, the internal creation of a complete set of innovation-facilitating resources may not, in fact, be the most desirable goal. Real options reasoning suggests that a firm's technological innovation interests may be well served by simply maintaining the option to acquire the promising or proven technologies of others. Collaborative modes of innovation, where firms leverage partner resources, may represent more efficient paths of technology progress than internal development when a high technological "learning distance" exists among firms seeking to create and exploit technological innovations (Hoskisson & Busenitz, 2002).

Several managerial implications also flow from our observations and arguments. First, managers in firms either confronting or trying to initiate innovation should be receptive to obtaining from external sources the resources needed to create or exploit technological innovations. As mentioned above, complete sets of technology- and non-technology-based resources that facilitate progress through all stages of the technological innovation process may be uncommon among firms. However, given the "not-invented-here" emphasis that prevails in many firms, managers may not be naturally inclined to augment their firms' internal resources with complementary, externally acquired resources. Such a bias may predictably decrease a firm's ability to regularly appropriate rents from technological innovations.

Second, managers should consider corporate venturing as a means to create and/or exploit technological discontinuities. For example, large firms often avoid the bureaucratic constraints imposed by their control systems by spinning off entrepreneurial firms with seed money, while maintaining an interest in the spun-off unit and technology. The entrepreneurial firm is sometimes then brought back into the parent firm if the product/technology is sufficiently attractive to the parent. This approach has proved successful in facilitating innovation among large firms in Japan (Ito, 1995). Significantly, this "external" approach to corporate venturing enables the new ventures to benefit from a parenting advantage (Campbell, Goold & Alexander, 1995) and concurrently operate in a more autonomous fashion outside the purview of the often-stifling corporate control system. Perhaps most importantly, by engaging in corporate venturing large firms become incubators for new businesses, thus possibly realizing the innovation-related benefits of large *and* small firms.

A final managerial implication of our observations and arguments is that managers of firms in dynamic industries must carefully weigh innovation mode options. Consistent with

Eisenhardt and Martin's (2000) concept of "equifinality," innovation can result from several different developmental paths. Firms can innovate through either internal development, by acquiring the innovative output of others, or through some collaborative arrangement. Depending upon the specifics of the situation, each of these innovation modes may be appropriate. The contexts within which each of these innovation modes are optimal have not been fully specified within the literature; however, research by Hoskisson and Busenitz (2002), Lengnick-Hall (1991), and Zahra and Covin (1994) has addressed this issue. The principal challenges for managers may be to recognize that innovation is not always best accomplished through the same developmental path; to identify criteria that facilitate the choice of the most appropriate developmental path(s); and to respond accordingly.

From a broader economic perspective, the observations of this paper may also be important. There are implications for policy makers in the areas of business development and antitrust. Regarding business development, policy makers must recognize that legislation that positively affects small firms may have social and economic benefits beyond those firms due to the symbiotic relationship that often exists between large and small firm resources at different stages of an industry' technological evolution. As such, investments in small firms in the form of tax breaks or government financing programs, for example, may yield particularly high returns. Related to this point, industry-level technology advances from innovation may be contingent upon having an appropriate mix of large and small firms. This "mix" is necessary due to the common co-dependence of small and large firms for the purpose of fully exploiting technological innovations. Although support for small firms is embraced in the United States, it is less established in other nations. For example, the Japanese Diet first passed laws promoting the creation of small and medium-size firms in 1999 (METI, 2002).

Regarding antitrust issues, the competitive environment in dynamic, technology-based industries is different than in more stable industries where critical, advantage-sustaining resources are sometimes easier to monopolize. Antitrust policy should consider the rate of observed and anticipated technological change in an industry. The market power of firms in dynamic, technology-based industries is not just a function of firm size but of the "completeness" of the firm's technology- and non-technology-based resources. If, as this paper suggests, firm size is systematically related to the presence of certain innovation-relevant resources and capabilities whose value (i.e., ability to contribute to the firm's competitive strength) is likely to vary across the stages of the technological innovation process, then larger firms may not be as inherently advantaged in technologically dynamic industries as in other industries. In short, a more conservative definition of what constitutes a monopoly situation may be appropriate in dynamic, technology-based industries where large size may not confer lasting competitive advantages.

Limitations and Future Research

Several limitations are inherent to our theory development and propositions, and appropriate qualifications should be acknowledged. Three qualifications are, perhaps, most noteworthy. First, the collaborative efforts between large and small firms discussed in our paper are not inevitable but simply possible arrangements through which technology advances might be made. Certainly many small firms innovate and grow without the direct collaborative involvement of large firms, and vice versa. Second, our arguments rely on several generalizations concerning the resources and attributes typical of large and small firms. The predictive accuracy of our propositions will likely be a function of whether the specific firms in question have the assumed types of resources and attributes. Third, our discussion does not depict the complexity or full variety of possible associations between the key variables used to build the propositions. For example, our discussion does not address why some industries continue to operate with competing technology standards while others quickly converge around a single dominant design.

Various directions for future research are suggested by the preceding discussion. First, and most obviously, our propositions are offered for empirical verification. Future studies could test the predictive validity of these propositions. Longitudinal data and methods of analysis through which causation could be inferred would be needed since the passage of time is an inherent aspect of the propositions. Second, future research might productively focus on more fully delineating the determinants of effective large firm–small firm collaborative efforts. While some progress has been reported in this area (e.g., Eisenhardt & Schoonhoven, 1996; Hitt et al., 2001; Harrison et al., 2001), many fundamental uncertainties remain regarding why alliances assume certain forms, how and what parties contribute to alliances, and the effects of alliances and acquisition activity on performance. Additionally, while the current paper presented a resource-based justification for firm collaborations, non-resource-based explanations of collaborative efforts—including, for example, the effects of managerial opportunism, governance structure choices, and expectations of collaborating firms—may be equally (or more) valid and, thus, represent promising opportunities for future research. Finally, investigations into the means firms choose to appropriate rents from technological discontinuities represent a particularly promising and important research domain. Two broad and significant research questions might include: (1) What organizational, environmental, and strategic factors differentiate firms that effectively exploit technological discontinuities from those that do not? and (2) Under what circumstances do collaborative arrangements between firms facilitate or impede the appropriation of rents from technological discontinuities?

Acknowledgments

The authors thank Tricia McDougall, Marne Arthaud-Day and Brett Gilbert of Indiana University for their helpful comments on prior drafts of this paper, and Sean Gorman of Indiana University for his assistance with the literature review. Additionally, we thank David J. Ketchen Jr., the *JOM* Senior Associate Editor, and the anonymous reviewers for their many insights and suggestions.

References

Abernathy, W. J., & Utterback, J. M. 1988. Innovation over time and in historical context: Patterns of industrial innovation. In M. L. Tushman & W. L. Moore (Eds.), *Readings in the management of innovation* (2nd ed.): 25–54. Cambridge, MA: Ballinger Publishing Company.

Acs, Z. J., & Audretsch, D. B. 1988. Innovation in large and small firms: An empirical analysis. *American Economic Review*, 78: 678–690.

Acs, Z. J., Audretsch, D. B., & Feldman, M. P. 1994. R&D spillovers and recipient firm size. *The Review of Economics and Statistics*, 76: 336–340.

Ahuja, G., & Katila, R. 2001. Technological acquisitions and the innovation performance of acquiring firm: A longitudinal study. *Strategic Management Journal*, 22: 197–220.

Ahuja, G., & Lampert, C. M. 2001. Entrepreneurship in the large corporation: A longitudinal study of how established firms create breakthrough inventions. *Strategic Management Journal*, 22: 521–543.

Alvarez, S. A., & Barney, J. B. 2001. How entrepreneurial firms can benefit from alliances with large partners. *Academy of Management Executive*, 15(1): 139–148.

Anderson, P., & Tushman, M. L. 1990. Technological discontinuities and dominant designs: A cyclical model of technological change. *Administrative Science Quarterly*, 35: 604–633.

Audretsch, D. B. 1999. *The economic role of small- and medium-sized enterprises: The United States*. Presented at the World Bank Workshop on Small and Medium Enterprises, August 13–14, New York.

Audretsch, D. B., Weigand, J., & Weigand, C. 2000. Does the small business innovation research program foster entrepreneurial behavior? Evidence from Indiana. In C. W. Wessner (Ed.), *The small business innovation research (SBIR) program: An assessment of the Department of Defense Fast Track initiative*. Washington, DC: National Academy Press.

Baldwin, W. L., & Scott, J. T. 1987. *Market structure and technological change*. New York: Harwood Academic Publishers.

Baum, J., & Oliver, C. 1991. Institutional linkages and organizational mortality. *Administrative Science Quarterly*, 36: 187–218.

Baysinger, B. D., & Hoskisson, R. E. 1989. Diversification strategy and R&D intensity in large multiproduct firms. *Academy of Management Journal*, 32: 310–332.

Berry, M. M. J., & Taggart, J. H. 1994. Managing technology and innovation: A review. *R&D Management*, 24(4): 341–353.

Bittlingmayer, G. 1996. Merger as a form of investment. *KYKLOS*, 49: 127–153.

Bower, J. L., & Christensen, C. M. 1993. Disruptive technologies: Catching the wave. *Harvard Business Review*, 73(1): 43–53.

Burgelman, R. A., Maidique, M. A., & Wheelwright, S. C. 2001. *Strategic management of technology and innovation*. Boston: McGraw-Hill/Irwin.

Campbell, A., Goold, M., & Alexander, M. 1995. Corporate strategy: The quest for parenting advantage. *Harvard Business Review*, 73: 120–132.

Capron, L. 1999. The long-term performance of horizontal acquisitions. *Strategic Management Journal*, 20: 987–1018.

Carlton, J. 1998. It seems like yesterday: The PC has come a long way and quickly. *Wall Street Journal*, 16: R10.

Chen, M., & Hambrick, D. C. 1995. Speed, stealth, and selective attack: How small firms differ from large firms in competitive behavior. *Academy of Management Journal*, 38: 453–482.

Christensen, C. M. 1997. *The innovator's dilemma*. Boston: Harvard Business School Press.

Christensen, C. M., & Bower, J. L. 1996. Customer power, strategic investment, and the failure of leading firms. *Strategic Management Journal*, 17: 197–218.

Cohen, W. M., & Klepper, S. 1992. The anatomy of industry R&D intensity distributions. *American Economic Review*, 82: 773–799.

Cooper, A. C., & Smith, C. G. 1992. How established firms respond to threatening technologies. *Academy of Management Executive*, 6(2): 55–69.

Cooper, A. C., & Schendel, D. 1976. Strategic responses to technological threats. *Business Horizons*, 19(1): 61–69.

Courtney, H., Kirkland, J., & Viguerie, P. 1997. Strategy under uncertainty. *Harvard Business Review*, 77(6): 66–79.

Covin, J., Prescott, J., & Slevin, D. 1990. The effects of technological sophistication on strategic profiles, structure, and firm performance. *Journal of Management Studies*, 27: 485–510.

Das, T. K., & Teng, B. 1998. Resource and risk management in the strategic alliance making process. *Journal of Management*, 24: 21–42.

Davidson, K. M. 1991. Why acquisitions may not be the best route to innovation. *The Journal of Business Strategy*, 12: 50–52.

Dyer, J. H., & Singh, H. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23: 660–679.

Eisenhardt, K. M., & Martin, J. A. 2000. Dynamic capabilities: What are they? *Strategic Management Journal*, 21: 1105–1121.

Eisenhardt, K. M., & Schoonhoven, C. B. 1996. Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms. *Organization Science*, 7: 136–150.

Ferguson, C. H. 1988. From the people who brought you voodoo economics. *Harvard Business Review*, 88: 49–61.

Freeman, C., & Soete, L. 1997. *The economics of industrial innovation*. Cambridge, MA: The MIT Press.

Gerpott, T. J. 1995. Successful integration of R&D functions after acquisitions: An exploratory empirical study. *R&D Management*, 28: 161–178.

Gilder, G. 1988. The revitalization of everything: The law of the microcosm. *Harvard Business Review*, 88: 49–61.

Goodman, R. A., & Lawless, M. W. 1994. *Technology and strategy: Conceptual models and diagnostics*. New York: Oxford University Press.

Goold, M., & Campbell, A. 1987. *Strategies and styles: The role of the centre in managing diversified corporations*. New York: Blackwell.

Hadegdoorn, J. 1993. Understanding the rationale of strategic technology partnering: Interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal*, 14: 371–385.

Hamilton, W. F. 1985. Corporate strategies for managing emerging technologies. *Technology in Society*, 7: 197–212.

Hamilton, J., & Himmelstein, L. 1997. A wellspring called Stanford. *Businessweek*: 25, 82–84.

Harrison, J. S., Hitt, M. A., Hoskisson, R. E., & Ireland, R. D. 2001. Resource complementarity in business combinations: Extending the logic to organizational alliances. *Journal of Management*, 27: 679–690.

Haspeslagh, P. C., & Jemison, D. B. 1991. *Managing acquisitions: Creating value through corporate renewal*. New York: The Free Press.

Hitt, M. A., Harrison, J. S., & Ireland, R. D. 2001. *Mergers and acquisitions: A guide to creating value for stakeholders*. Oxford, UK: Oxford University Press.

Hitt, M. A., Hoskisson, R. E., Ireland, R. D., & Harrison, J. S. 1991. Effects of acquisitions on R&D inputs and outputs. *Academy of Management Journal*, 34: 693–706.

Hitt, M. A., Hoskisson, R. E., Johnson, R. A., & Moesel, D. D. 1996. The market for corporate control and firm innovation. *Academy of Management Journal*, 39: 1084–1119.

Hitt, M. A., & Ireland, R. D. 2000. The intersection of entrepreneurship and strategic management research. In D. L. Sexton & H. Landstrom (Eds.), *The Blackwell handbook of entrepreneurship*: 45–63. Oxford, UK: Blackwell.

Hitt, M. A., Ireland, R. D., & Hoskisson, R. E. 1999. *Strategic management competitiveness and globalization* (3rd ed). Cincinnati, OH: South-Western College Publishing.

Hoskisson, R. E., & Busenitz, L. W. 2002. Market uncertainty and learning distance in corporate entrepreneurship entry mode choice. In M. A. Hitt, R. D. Ireland, S. M. Camp, & D. L. Sexton (Eds.), *Strategic entrepreneurship: Creating a new mindset*: 151–172. Oxford, UK: Blackwell.

Hoskisson, R. E., & Johnson, R. A. 1992. Corporate restructuring and strategic change: The effect on diversification strategy and R&D intensity. *Strategic Management Journal*, 13: 625–634.

Hudson, B. T. 1994. Innovation through acquisition. *The Cornell HRA Quarterly*: 82–87.

Ito, K. 1995. Japanese spinoffs: Unexplored survival strategies. *Strategic Management Journal*, 16: 431–446.

Kamien, M. I., & Schwartz, N. L. 1982. *Market structure and innovation*. Cambridge, UK: Cambridge University Press.

Kim, L. 1988. Entrepreneurship and innovation in a rapidly developing country. *Journal of Development Planning*, 18: 183–194.

Klepper, S. 1996. Entry, exit, growth, and innovation over the product life cycle. *American Economic Review*, 86: 562–583.

Kogut, B. 1991. Joint ventures and the option to expand and acquire. *Management Science*, 37: 19–33.

Kor, Y. Y., & Mahoney, J. T. 2000. Penrose's resource-based approach: The process and product of research creativity. *Journal of Management Studies*, 37: 109–139.

Lawless, M. W., & Anderson, P. C. 1996. Generational technological change: Effects of innovation and local rivalry on performance. *Academy of Management Journal*, 39: 1185–1217.

Lengnick-Hall, C. A. 1991. A conceptual framework for evaluating designs for corporate innovation. *Journal of Engineering and Technology Management*, 7(3/4): 197–227.

Lieberman, M. B., & Montgomery, D. B. 1998. First-mover (dis)advantages: Retrospective and link with the resource-based view. *Strategic Management Journal*, 19: 1111–1125.

Loescher, S. M. 1984. Bureaucratic measurement, shuttling stock shares, and shortened time horizons: Implications for economic growth. *Quarterly Review of Economics and Business*, 24(4): 8–23.

Lowe, J., & Taylor, P. 1998. R&D and technology purchase through license agreements: Complementary strategies and complementary assets. *R&D Management*, 28: 263–279.

Lynn, G. S., Morone, J. G., & Paulson, A. S. 1996. Marketing and discontinuous innovation: The probe and learn process. *California Management Review*, 38: 8–37.

MacDonald, J. M. 1985. R&D and the directions of diversification. *The Review of Economics and Statistics*, 67: 583–590.

McGrath, R. G. 1999. Falling forward: Real options reasoning and entrepreneurial failure. *Academy of Management Review*, 24: 13–30.

McGrath, R. G., & MacMillan, I. C. 2000. Assessing technology projects using real options reasoning. *Research Technology Management*, 43: 35–49.

Mezias, S. J., & Glynn, M. A. 1993. The three faces of corporate renewal: Institution, revolution, and evolution. *Strategic Management Journal*, 14: 77–101.

Ministry of Economy, Trade, and Industry (METI). 2002. Available: http://www.chusho.meti.go.jp/english/index.htmil.

Nelson, R. R., & Winter, S. G. 1978. Forces generating and limiting concentration under Schumpeterian competition. *Bell Journal of Economics*, 9: 524–548.

Pablo, A. L. 1994. Determinants of acquisition integration level: A decision-making perspective. *Academy of Management Journal*, 37: 803–838.

Parkhe, A. 1993. Strategic alliance structuring: A game theoretic and transaction cost examination of interfirm cooperation. *Academy of Management Journal*, 36: 794–829.

Pavitt, K., Robson, M., & Townsend, J. 1987. The size distribution of innovating firms in the UK: 1945–1983. *The Journal of Industrial Economics*, 35: 297–316.

Porter, M. E. 1990. *The competitive advantage of nations*. New York: The Free Press.

Porter, M. E. 1998. Clusters and the new economics of competition. *Harvard Business Review*, 76(6): 77–90.

Roberts, E. B. 1980. New ventures for corporate growth. *Harvard Business Review*, 58(4): 134–142.

Roberts, E. B., & Berry, C. A. 1985. Entering new businesses: Selecting strategies for success. *Sloan Management Review*, 27: 3–17.

Rodgers, T. J. 1990. Landmark messages for the microcosm. *Harvard Business Review*, 68(1): 2–6.

Rosen, R. J. 1991. Research and development with asymmetric firm sizes. *RAND Journal of Economics*, 22: 411–429.

Rothwell, R., & Dodgson, M. 1991. External linkages and innovation in small and medium-sized enterprises. *R&D Management*, 21: 125–137.

Scherer, F. M. 1980. *Industrial market structure and economic performance* (2nd ed.). Chicago: Rand McNally.

Scherer, F. M. 1991. Changing perspectives on the firm size problem. In Z. J. Acs & D. B. Audretsch (Eds.), *Innovation and technological change: An international comparison*: 24–38. Ann Arbor, MI: The University of Michigan Press.

Schnaars, S. P. 1994. *Managing imitation strategies: How later entrants seize markets from pioneers*. New York: The Free Press.

Schumpeter, J. A. 1934. *The theory of economic development*. New Brunswick, NJ: Transaction Publishers.

Schumpeter, J. A. 1942. *Capitalism, socialism, and democracy*. New York: Harper Perennial.

Sen, F. K., & Egelhoff, W. G. 2000. Innovative capabilities of a firm and the use of technical alliances. *IEEE Transactions on Engineering Management*, 47: 174–183.

Sharma, A. 1999. Central dilemmas of managing innovation in large firms. *California Management Review*, 41: 146–164.

Singh, K. 1997. The impact of technological complexity and interfirm cooperation on business survival. *Academy of Management Journal*, 40: 339–367.

Stringer, R. 2000. How to manage radical innovation. *California Management Review*, 42: 70–88.

Teece, D. J. 1982. Towards an economic theory of the multiproduct firm. *Journal of Economic Behavior and Organization*, 3: 39–63.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15: 285–305.

Teece, D. J. 2000. *Managing intellectual capital*. New York: Oxford University Press.

Tegarden, L. F., Hatfield, D. E., & Echols, A. E. 1999. Doomed from the start: What is the value of selecting a future dominant design? *Strategic Management Journal*, 20: 495–518.

Tushman, M. L., & Romanelli, E. 1985. Organizational evolution: A metamorphosis model of convergence and reorientation. *Research in Organizational Behavior*, 7: 171–222.

Utterback, J. M., & Abernathty, W. J. 1975. A dynamic model of process and product innovation. *Omega*, 33: 639–656.

Utterback, J. M., & Afuah, A. N. 1995. The dynamic "Diamond": A technological innovation perspective. *Working Paper 138-95*. MIT: Cambridge, MA.

Wernerfelt, B. 1988. Umbrella branding as a signal of new product quality: An example of signaling by posting a bond. *RAND Journal of Economics*, 19(3): 458–466.

Williamson, O. E. 1975. *Markets and hierarchies: Analysis and antitrust implications. A study of the economics of internal organization*. New York: The Free Press.

Yearly, S. 1988. *Science, technology, and social change*. London: Unwin Hyman.

Zahra, S. A. 1996. Technology strategy and new venture performance: A study of corporate-sponsored and independent biotechnology ventures. *Journal of Business Venturing*, 11: 289–321.

Zahra, S. A., & Covin, J. G. 1994. The financial implications of fit between competitive strategy and innovation types and sources. *Journal of High Technology Management Research*, 5(2): 183–211.

Zahra, S. A., Nash, S., & Bickford, D. J. 1995. Transforming technological pioneering into competitive advantage. *Academy of Management Executive*, 9(1): 17–31.

David R. King is a Major in the United States Air Force and completed his Ph.D. in strategic management at the Kelley School of Business, Indiana University. Major King has previously served as an Assistant Professor in the Management Department of the United States Air Force Academy. His current research interests include technology innovation, technology transfer, and mergers and acquisitions in high-technology settings. Major King currently manages weapons procurement programs in the Pentagon.

Jeffrey G. Covin is the Samuel and Pauline Glaubinger Professor of Entrepreneurship at the Kelley School of Business, Indiana University. Professor Covin received his Ph.D. in Organization Studies and Strategic Planning from the University of Pittsburgh. He teaches in the fields of entrepreneurship, strategic management, and technology management. His current research interests include the strategic use of corporate entrepreneurship, decision-making styles that promote firm performance in various industry contexts, and competitive strategy among high-technology firms. Professor Covin's research has been published in several of the top journals in the fields of entrepreneurship, strategic management, and technology management. He has won several teaching and research awards.

W. Harvey Hegarty is Professor of Administrative Studies at the Kelley School of Business at Indiana University. His research interests include: individual and organizational differences in creativity, the role of reputation in evolving organizations, and strategic and operational issues in transitional economies. His teaching spans a wide range of courses and many international opportunities. Outside passions include: grandchildren, downhill skiing, and just about anything he has not tried before.