1 Technological innovation: Oversights and foresights

Raghu Garud, Praveen R. Nayyar, and Zur Shapira

Technological changes offer firms some of the most important opportunities for maintaining corporate vitality. Indeed, there are many well known cases of firms capitalizing on technological opportunities. For instance, Sun Microsystems was among the first few firms in the computer industry to initiate the development of RISC chips that are now revolutionizing the computer industry (Alster, 1987). 3M has reaped benefits from its Post-it Notes as has Sony from its Walkman (Nayak & Kettingham, 1986). There are many other instances of such “technological foresights.”

There are also several instances of firms failing to capitalize on technological opportunities. For instance, RCA, a recognized leader in broadcasting, chose not to invest in FM technology (Hughes, 1989). Xerox Corporation was among the first few firms to develop many of the elements of the personal computer that we now use but was unable to reap commercial benefits from its efforts (Smith & Alexander, 1988). There are many other instances of such “technological oversights.”

Why do such technological oversights and foresights occur? One view is that oversights and foresights are inevitable because technological outcomes are uncertain and contingent upon a match between the internal capabilities of a firm and its external environments, and because technological choices are complex and constrained by the past. These are the challenges that the chapters in this book attempt to address in an effort to develop a theory of technological innovation.

Challenges to the creation of a theory of technological innovation

Uncertainty

The uncertainty challenge is richly illustrated by Barney (chapter 2, this volume) in his use of a coin-flipping analogy to suggest “luck” as an explana-
tion of technological oversights and foresights. This challenge is all the more acute in the case of technological innovation wherein outcomes are less certain than the outcomes from the flip of a fair coin. By some accounts, only two out of 10 innovations succeed (Mansfield, 1981; Cooper & Klein-schmidt, 1990; Van de Ven, 1986; Rosenberg, 1994). Indeed, pushing this perspective a bit further, oversights and foresights cannot be determined ex-ante and are constructs that can only be applied post-hoc.

Contingency

Coins are flipped knowing ex-ante whether heads or tails constitutes a positive outcome. However, judging outcomes of technological innovation as successes or as failures is more difficult. This is because whether or not an endeavor leads to a positive or negative outcome is contextually determined (Langlois, chapter 5, this volume). Oversights and foresights, from this perspective, are contingent upon a match between internal competencies and external environments, the connections between which are often tenuous and emergent (March & Sproull, 1990). Moreover, these environments do not remain static. As these environments change, previous successes may be viewed as failures or vice versa. Thus, success or failure may only be determined post-hoc, although actions have to be taken ex-ante.

Constraints

In addition, choices made in the present are constrained by choices of the past. Successive investments in an approach, whether they be cognitive, behavioral, or economic, result in increasing momentum in a particular direction, thereby creating a "trajectory" (Dosi, 1982; Porac, chapter 8, this volume; Henderson, chapter 9, this volume). Such path dependencies (Arthur, 1988; David, 1985; Powell, 1991) can result in an escalation of commitment to a course of action that may be at odds with a different, larger emerging "reality" (Garud & Rappa, 1994; Levitt & March, 1988). Here again, outcomes of a technological choice made in the present are considered as oversights or as foresights only in hindsight (Utterback, 1994).

Complexity

To complicate matters, technology practitioners who make decisions in the present are subject to a number of biases (Bercovitz, Figueiredo, & Teece, chapter 13, this volume). Even if it did matter, human judgment is limited at best and biased as well. These limits and biases apply all the more so to situations involving complex decisions, as is usually the case with technological choices. These limits and biases result in technological choices that are viewed as foresights or oversights only in hindsight.

Given these challenges, it appears that Barney’s coin-flipping analogy may be too generous a metaphor when it comes to describing outcomes of technological innovations. In other words, innovations are not just "chancy," but are constrained by the past as well, even as humans with their limited cognitive resources make complex decisions in a changing contextu-lized world. If we were to flip an unbiased coin, we might have a 50/50 chance of success. Outcomes from technological innovation appear to be bleaker. Under these conditions, only hindsight is 20/20.

Beating the odds: Towards a theory of technological innovation

To construct a theory of technological innovation, we must suggest how it is possible to enhance the slim odds of technological success, which can be known only in the future, by adopting practices in the present, given (and despite) our pasts. Specifically, we must identify ways to deal with the complexities associated with technological choices to systematically influence outcomes. We must demonstrate how it is possible for us to escape our past in order to create a new future. Moreover, we must establish that practitioners actively try to tailor a fit between their “external” environments and “internal” competencies.

Learning to flip coins

Chapters in the next section address the challenge arising from uncertainty. The section begins with Barney’s chapter, which suggests that technological foresights and oversights are simply lucky outcomes of a random process. One way to address this challenge is to aggregate outcomes across units and time, to learn from each “experiment” so that the odds of success may increase across units and time. This is what we (Garud, Nayyar, and Shapira) propose in chapter 3. Dosi and Love (chapter 4) suggest that even if learning does not occur, individual experiments create alternatives to choose from (see also Levinthal, chapter 10, this volume).

Tailoring fits

The third section addresses the contingent nature of outcomes. Beginning with a chapter by Langlois (chapter 5) that articulates the problem, the section continues with a chapter by Brown (chapter 6) that suggests why and how fits can be tailored by firms as they enact their realities. Similar to Weick’s (1979) notion of enactment and March’s (1991) notion of exploration, Brown suggests that “Our jobs is to be there as markets evolve, to learn to recognize them even before they recognize themselves, because we can’t afford to wait for the clarity of hindsight as we construct linkages between emerging markets and emerging technologies. We allow technologies to shape markets and the markets to shape the technologies.” Amabile and
Conti’s chapter (chapter 7) also explores this issue, but by examining the context for fostering creativity within organizations. They argue that many of the downsizing efforts currently underway in organizations can adversely affect employee motivations to engage in innovative activities. Amabile and Conti then offer several suggestions as to how this negative facet of downsizing may be overcome.

Remembering to forget

Chapters in the fourth section explore how it might be possible to attenuate the links with the past to reduce its constraining effects. The challenge is articulated by Porac (chapter 8) who argues that technological trajectories are “sticky” in the sense that past actions and choices constrain the present and the future. Henderson (chapter 9), too, offers insights on how past beliefs about the potentials of a technology might constrain its limits. Reflecting on similar issues, Levinthal (chapter 10) points out that the codification of past experiences, considered as “wisdom” in stable environments, acts as inertial forces in changing environments. Consequently, Levinthal argues that unlearning may be required for “discovery.” Jelinek (chapter 11) too is mindful of the need to create new initiatives in mature industries. She suggests that substantial entrepreneurship is required on the part of members who perform organizationally “unnatural” and “illegitimate” acts. She suggests that such “unnatural” and “illegitimate” acts can be cultivated through the pervasive sharing of managerial tasks and responsibilities, mindful alertness to anomalies, and ambiguity absorption by means of mutual support. Elashberg, Lilien, and Rao (chapter 12) point out that the use of many market research tools may accentuate the problems of the past when technology practitioners extrapolate from them. These authors offer tools that are appropriate to probe the future rather than the past.

(S)top management and culture

The fifth section addresses the role of top management in dealing with complexity. Bercovitz, Figueiredo, and Teece (chapter 13) articulate the challenge of complexity. Specifically, they highlight the biases inherent in making decisions on complex issues. Murmann and Tushman (chapter 14) illustrate how the collective mobilization of innovation intelligence through the presence of a diversity of perspectives in top-management teams is fundamental to dealing with the complexities associated with innovation. Van de Ven and Ginzman (chapter 15) have a similar message. They suggest that it is important to put in place dialectical processes to overcome the potential myopia that might develop during technological innovations. However, Fischhoff, Laniir, and Johnson (chapter 16) and Kunda (chapter 17) caution that top-management intervention can create unintended side effects. Specifically, top-management intervention may decrease the possibility of autonomous innovation (Fischhoff, Laniir & Johnson, chapter 16, this volume), or might create a subtle cultural context in which innovating members “burn” themselves out in the quest of a task that by its very nature can never be completed (Kunda, chapter 17, this volume).

In sum, the challenges to a theory of innovation stem from the fact that technological outcomes are uncertain and contingent upon a match between firms’ internal capabilities and external environments, even as technological activities are complex and constrained. These are powerful ideas. The underpinnings to a theory of technological innovation lie in an equally enticing set of ideas. Specifically, technological outcomes can be systematically enacted to overcome constraints of the past by managing complexity in the present.

Learning makes the difference

By themselves, the terms technological overtakes and foresights focus attention on innovation as outcomes. Such a focus creates a roadblock to the construction of a theory of technological innovation. Focusing on outcomes alone can result in “functional” thinking, wherein we begin rationalizing how and why oversights and foresights may have occurred only in hindsight.

To gain potency, oversights and foresights as outcomes have to be part of a larger process. Indeed, learning is a key process that distinguishes technological innovation as a game of chance from one that is a game that involves skill as well. Without learning (or unlearning as the case might be) technological choices are indeed just “coin flips.” With the introduction of learning, however, technological innovation becomes an activity that possesses the potential to be systematic, enacted, unconstrained, and manageable.

Indeed, each chapter in this book has several implications for the notion of learning as applied to technological choices over a period of time, though their meanings and applications differ. For instance, the notion of learning, associated with the organizing theme in the second section, results from repeated choices that are made possible by aggregating across time and entities. In contrast, the notion of learning implicit in the theme of the third section has to do with the recognition and creation of a match between an external environment (that is not fully in a firm’s control) and internal capabilities (that create a certain cognitive mind-set). Most interestingly, the notion of learning is inextricably intertwined with notions of unlearning for chapters in the fourth section. Learning results in the creation of a stock of knowledge that might need to be abandoned to create a “launching ground” for new learning in an attempt to accumulate contemporary useful knowledge. Learning, from the perspective of the fifth section, has to do with a combination of the above approaches as practitioners attempt to manage technological innovations in a complex and messy world.

Each chapter is a richer mosaic of ideas about learning and unlearning.
than we have attributed to them. The important point to note is that if we have to create a useful theory of technological innovation, the notion of learning, in its various forms, is fundamental. We (Garud, Nayyar, and Shapira) return to these issues once again in the conclusion of the book (chapter 18) in which we provide our readers a way to integrate the various themes in this book. In doing so, we take the first steps towards creating a theory of technological innovation that entertains the proposition that it is possible to “beat the odds.”

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Notes

1 See Utterback (1994), he uses the metaphor of innovation as a game of “chutes and ladders” to suggest that overights and foresights are inevitable.

2 These chapters are richer than the conceptual “boxes” that we have put them into. Indeed, it is important to note that these boxes emerged inductively as we experimented with various combinations and approaches to the organization of the book. When we first conceptualized this book, we had the various contributors organized by disciplines (technology, marketing, decision making, organizational processes, and strategy). We found that such an organizing scheme created artificial disciplinary barriers to a phenomenon that is truly interdisciplinary. We then tried to organize the book by “levels” of analyses. We soon discovered that many chapters cut across levels. The current scheme, although committing a “pragmestian transformation” of its own, nevertheless represents elements of a theory of technological innovation.

References


Beating the odds: Towards a theory of technological innovation

Raghu Garud, Praveen Nayyar, and Zur Shapira

At the Museum of Natural History in New York, a series of panels graphically depicts natural selection at work. In one panel, a fox runs after a rabbit. In another, a tiger is poised to kill a fox. And so on.

To survive, each animal must rely on the competitive advantages stemming from its own unique abilities. Nothing else matters. Ultimately, outcomes are inevitable and determined. There is no choice in such a world. All that animals have to rely on is what they do best. Pursued by a fox, it makes a lot of sense that a rabbit should run as fast as possible. In the circumstances, it is the best thing to do. Looking at the panel, though, it is not clear that running will be enough to save the rabbit.

The inevitability of outcomes in such a naturally selected world strikes home as one gazes at a magnificent display of dinosaurs. Despite their size, and indeed because of it, dinosaurs became extinct when the earth’s atmospheric temperatures soared when either a volcanic eruption occurred or a meteorite hit the earth. Helpless to adapt, dinosaurs became extinct as a species, to be replaced by others better suited to survive the changed ambient conditions.

Subsumed in the natural selection process depicted in these panels are the four challenges to a theory of technological innovation that we articulated (Garud, Nayyar, and Shapira, chapter 1, this volume). These challenges stem from the inevitability of the occurrence of technological oversights and foresights. Oversights and foresights are inevitable because technological outcomes are uncertain and contingent upon a match between the internal capabilities of a firm and its external environments. Furthermore, oversights and foresights are inevitable because technological choices are complex even as they are constrained by the past. From the perspective of a natural selection process, uncertainty stems from random variations, contingencies arise as selection environments change exogenously, and constraints are
created through an imprinting process where past experiences are retained. Needless to say, the complexity that is inherent in this natural selection process is dealt with without the presence of human intelligence (Figure 18.1).¹

Progressing from the section displaying primates to the section displaying humans at the Museum of Natural History, one senses an important difference. The panels no longer suggest creatures trapped with only the competencies they were endowed with at birth. Rather, the panels imply that humans have the wherewithal to use technologies to extend their physical and cognitive abilities and accomplish tasks they have not achieved before. One gets the sense that humans can not only respond to the world or shape it in ways that match their competencies, but that they also have the ability to abandon their past and create a new future. This flexibility is hinted at, for example, in the contrasts between the panel displaying kens men wearing animal skins to protect themselves from the Arctic cold, and the adjoining panel featuring an aborigine wearing a loin cloth to help him survive the sweltering desert heat.

These images evoke thoughts about how humans adapt to different environments. They also remind us of the enormous impact humans have had in shaping the world as we now know it. Indeed, the world we interact with is, increasingly, not a natural one, but an artificially created one. In this constructed world, variations are not always random, nor do selection environments preexist. Moreover, humans are not relatively powerless, like animals, for they do not have to enact scripts based only on the past.

It is this proposition that we would like to develop in our attempts at developing a theory of technological innovation. Specifically, we would like to highlight a technologically created world; one where it is possible to prepare for serendipity, where fits can be tailored, and where individuals have the power to bring about change through continuity. Shaping this process are humans, who, through the use of their cognitive abilities, can manage the complexities associated with technological innovation (Weick, 1990) (see Figure 18.2).

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**Figure 18.1.** Challenges to the construction of a theory of technological innovation.

**Figure 18.2.** Toward a theory of technological innovation.

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**Innovation in a technological world**

3M Corporation is most admired for its ability to sustain itself based on technological innovation. 3M's corporate aim is to generate 25% of its revenue from products introduced in the past 5 years. It appears that 3M has been able to meet this target regularly for over 20 years; a record that suggests that it might be possible for a firm to beat the "coin-flip" challenge offered by Barney (this volume).²

How can a firm such as 3M corporation systematically beat the odds associated with natural selection or subsumed in the coin flip analogy? An answer may lie in the now often repeated story of how "Post-it" notes were created (Nayak and Keteringham, 1986; Video on In Search of Excellence). It appears that an adhesive was created that was not appropriate for traditional purposes. Under most circumstances, such a product would have been considered a "failure." Not at 3M, however. Ever mindful of the problems of marking certain pages of the Bible, Art Fry, a research scientist at 3M Corporation, conceived of a use for the "failed" adhesive by conceptualizing a new product that was both "permanent and yet temporary." As told by Art and Lew Lehr (then CEO of 3M Corporation), this product was carefully introduced within 3M and in other institutional arenas before it was finally offered to the market.

The Post-it notes story suggests how individually and collectively hu-
Preparing for serendipity

We all know of Louis Pasteur’s famous adage “fortune favors the prepared mind.” Such a statement is reminiscent of other moments of insight in the lives of individuals such as Newton and Archimedes. More generally, it appears that the notion of creativity can be a cultivated phenomenon (Amabile and Conti, this volume, chapter 7).

To appreciate how it might be possible to cultivate creativity, it is important to have a theory of change that goes beyond considering creativity as comprising acts of genius that occur in random. Usher (1954) offers such a theory. He suggests that the emergence of novelty is a cumulative synthesis of a number of steps that include “perception of a problem,” the “setting of a stage,” an “act of insight,” and finally an “act of critical revision.” Such a process is similar to Koestler’s (1964) theory of “bisociation,” a process whereby creative people associate ideas from unrelated fields to create a totally new one.

Cumulative synthesis is a process that has evolutionary antecedents but revolutionary consequences. This view underscores the potentially dysfunctional consequences of aiming for either evolutionary or revolutionary innovations. For instance, the dysfunctional aspects of adopting a “breakthrough” mentality are well documented by Rosenbloom and Cusumano (1988) in their study of the evolution of VCR technology. They show that early pioneers who embraced a breakthrough mentality lost out to others who adopted a more consistent and pragmatic approach that can best be described as a process of “learning-by-trial.” The dysfunctional aspect of adopting only an evolutionary mentality is illustrated by the ways in which American firms got caught up within a given frame of thinking that can best be described as “just-in-case.” Consequently, many American firms failed to recognize the benefits of adopting a “just-in-time” approach.

The cumulative synthesis approach requires a mindset towards innovation that is very different from a mindset traditionally adopted in industry. Specifically it requires individuals to continually experiment with old and new ideas, probing the world around them to learn which endeavors might be successful (Eliashberg, Lilien, & Rao, this volume, chapter 12), which may need to be shelved for the future, and which must be abandoned. Institutions are not mechanisms to sanction individuals for “failed” efforts, but are devices for the retention of knowledge from “experiments.” In this way of thinking, initiatives, whether they lead to immediate successes or not, are neither oversights nor foresights, but are “probes” from which individuals can learn (Garud, Nayyar, and Shapira, chapter 3, this volume). Indeed, these initiatives create the very variations from which a larger collective can choose (Dosi and Lovelock, chapter 4; Levinthal, chapter 10, both this volume).

Tailoring fits

Unlike animals, humans are capable of “waiting” (Eister, 1983). Specifically, humans are capable of refusing favorable opportunities in the present in order to create even more favorable ones in the future. In the terminology introduced by March (1991), humans can forgo “exploitation” in the present in order to “explore” more favorable opportunities for the future.

An ability to wait and explore generates an “options value” to technological innovation (Kumaraswamy, 1996). Such an options value stems from the asynchronies that exist in the creation of ideas, markets, and institutions required for the successful implementation of technological innovations (Garud & Nayyar, 1994). As Cohen, March, and Olsen (1972) have pointed out in an organizational context, garbage can systems extract options value from innovations by facilitating the coupling of solutions with problems across time and space. Indeed, as Wilson and Flavack (1984) found, most innovations “unshelved” by firms were successful in comparison to a hit rate of two out of 10 that is typical of normal innovations (Mansfield, 1981).

Waiting and exploration also allows for the coevolution of firm capabilities, customer preferences, and institutional rules over time. Coevolutionary dynamics are necessary if we recognize that customer preferences are not given ex-ante, but can be institutionally shaped and molded (March, 1971). Similarly, markets and institutional infrastructures do not preexist, but must be created. Indeed, as Hirsch, (1975) has demonstrated, institutional environments can be coopted and shaped to create the appropriability regimes required to benefit from innovations (Teece, 1987).

From this way of thinking, the “temporary-permanent” attribute of Post-it is not given ex-ante, but one that is created. Similarly, the possibilities inherent in computer and information technologies do not preexist, but are continually shaped through a process of interaction between the providers, users, and other institutional players. In this sense, innovation itself is a negotiated activity, where ideas, markets, and institutions coevolve. In such a world, fits just don’t happen (Langlois, this volume), but must be tailored (Brown, this volume, chapter 6).

Change through continuity

The popular adage is that those who don’t know the past are condemned to repeat it. Particularly in environments characterized by rapid change,
though, there may be virtue in not knowing the past so well. Path dependencies and an emphasis on maintaining internal consistency constrain future possibilities (Porac, this volume; David, 1985; Arthur, 1988; Utterback, 1994, Levitt & March, 1988). In turn, if left unchecked, such a momentum may lead organizations to escalate their commitments to falling courses of action (Staw, 1981).

Several chapters in this book provide the rationale and the means to attenuate links with the past (e.g. Levinthal, chapter 10; Jelinek, chapter 11; Brown, chapter 6). However, the notions of cumulative syntheses (Usher, 1954) and bisociation (Koehler, 1964) suggest that it is important to go beyond the past even while building upon it. That is, we ought to think about accomplishing revolutionary outcomes with evolutionary strands.

Cumulative syntheses and bisociation require linkages between two or more seemingly unrelated ideas to create a new one. Such a process results in new functionality and performance that would not have been possible if the two dissociated ideas had not been associated. The act of creation and novelty requires both an in-depth understanding of each strand of knowledge, as well as an ability to bring these knowledge strands together in a powerful yet purposeful manner.

Such a process is best illustrated by the invention of the Sony Walkman (Nayak and Ketteringham, 1986). Challenged to create a personal stereo system, the engineering team, secluding from the rest, came up with many “out of the box” solutions using their in-depth understanding of various bodies of knowledge. The creation of a small set of speakers, however, was one area that stymied the team. The solution looking for a problem was identified by a “wandering chairman” who serendipitously discovered that a different group had created a set of speakers for which they did not have an immediate use. The act of creativity was one of coupling these two unrelated sets of activities.

A key lesson here is that what is considered possible is often institutionally and cognitively defined. These possibilities also become taken for granted (Henderson, chapter 9, this volume). As Geertz (1973) suggests, we become “creatures caught in webs of significance of our own making,” thereby reducing chances of coming up with a true innovation.

Another lesson is that new ideas are generated by building upon the old, thereby extracting the options value inherent in the innovation process. Such a view is very different from the views that generally abound about innovations. Most think of innovations as representing a break from the past. Such a perspective, however, creates a problem. A break from the past implies the creation of an idea that is “decontextualized” from existing knowledge streams and competencies, thereby increasing the likelihood of failure (Garud & Nayar, 1994). Indeed, as the “Post-it” notes case illustrates, both continuity and change have been hallmarks of innovation at 3M and in the occurrences of other “breakthroughs” (see Nayak & Ketteringham, 1986).

**Beating the odds**

Humans drive this process of innovation. On the one hand, the human brain is capable of very complex thoughts, including the envisioning of new phenomena. On the other hand, it also makes “Procrustean transformations” and then justifies them. Indeed, the human brain’s brilliance can also be its undoing. No matter what the phenomena are, we can come up with explanations and justifications, even as we constantly fall into retrospective rationality traps. Confronted with contrary evidence, we can come up with more powerful explanations that incorporate or dismiss such evidence and serve, ultimately, to further narrow the mind. We are also subject to a number of cognitive biases of which vividness, availability and anchoring are but a few (Bercovitz, de Figueiredo, & Tece, this volume, chapter 13; Tversky & Kahneman, 1974). Often, these biases are further reinforced through social interactions that lead to conformity, focus, and the elimination of alternative views (Janis & Mann, 1977). Furthermore, these biases are exacerbated by incentives that affect decision processes (Shapira, 1995).

A recognition of this duality creates the need for mechanisms that can compensate and expand the role of humans as they engage in the innovation process. For instance, Van de Ven and Grazman (chapter 15, this volume) suggest dialectical processes that can be found in the roles inherent in 3M’s innovation processes. Such a process operationalizes the notion of discrediting that Weick (1967) suggests – i.e., when we believe, we must disbelieve, and vice versa. Extending this perspective, Murmann and Tushman (chapter 14, this volume) suggest how cognitive limits can be extended through the collective mobilization of intelligence. These views acknowledge that creativity and cognition is as much an individual activity as it is a social one.

But the mobilization of collective intelligence comes at a price. Autonomous innovation can get dampened as induced and cultural processes take over (Fischhoff, Lanir & Johnson, chapter 16, this volume; Kunda, chapter 17, this volume). Consistent with the message that Bercovitz et al. (chapter 13, this volume) provide, it is therefore important to balance induced and autonomous sources of innovation (Burgelman, 1983).

**Beating the odds**

Challenges to a theory of technological innovation arise from the fact that outcomes are uncertain and contingent upon a match between internal capabilities and external environments, even as the process itself is complex and constrained by the past. An options value inherent in any creative act offers a way of addressing these challenges. Specifically, if we adopt an options perspective to technological innovations, it is possible to (1) reduce the downside uncertainties associated with innovation, (2) gain the time re-
required to tailor fits, (3) build upon the past even while departing from it, and (4) revel in the complexity associated with innovation, thereby allowing for chance events to create new ideas.

Implicit in our views on how we might create a useful theory of technological innovation is a perspective that variation, selection, and retention processes involve social and cognitive dimensions (Welch, 1979). Moreover, these processes coevolve (Figure 18.2). For instance, any innovation requires the creation of new technological, institutional, and marketing fields. In turn, these fields constrain future innovations. Successful firms such as 3M are able to convert such constraints into the very launching pads for future innovations. They use knowledge streams of the past to create new ideas for the future. Thus, continuity and change go hand in hand, tied together through a continual process of learning and unlearning.

The coevolutionary perspective draws attention to the fact that innovation is a process rather than an outcome. When considered as an outcome alone, the term innovation draws attention to concepts such as oversights and foresights that can be defined only in hindsight. However, as part of a larger process, these very outcomes become the bases by which technology entrepreneurs probe their worlds, create them, and decide on the time and place for the implementation of ideas. As Brown (chapter 6, this volume) noted: "You are forever aiming at targets you can’t see, or you don’t understand, or that change as a result of things you do." In such a conceptualization, one can see the makings of a theory of technological innovation wherein it is possible to "beat the odds."

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Notes

1. These issues can be mapped on to Van de Ven’s (1986) categories codifying innovation. Specifically, Van de Ven and his colleagues conceptualized innovations as changes in ideas, people, transactions, and contexts, leading to certain outcomes. Outcomes correspond to the notion of oversights and foresights that we have used, changes in ideas are surrounded by uncertainty, the notion of contexts raise issues about contingencies between the internal capabilities of a firm and its external environments, transactions evoke images of how the past can constrain the future, and, at the core of these processes are people who employ their cognitive abilities to either aid or abet the innovation process (see also Campbell, 1969).

2. Starting in 1993, 3M Corporation changed its goal to 50% of sales from new products in the last 4 years. In 1993, they did not meet this goal (although they met the 25% goal). They did accomplish the new goal in 1994 and expect to accomplish it for 1995 as well. Source: 3M Corporate Public Relations Department (1996).

References


