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Technology Cycles, Innovation Streams, and Ambidextrous Organizations: Organization Renewal Through Innovation Streams and Strategic Change

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THE CHALLENGE

Innovation and new product development are crucial sources of competitive advantage. After all the cost-cutting, downsizing and re-engineering, innovation and product development are levers through which firms can reinvent themselves. For example, Noika, Intel, Sony, Seiko, Corning, and Motorola have all generated sustained competitive advantage through continuous streams of incremental, architectural (the combination or linkage of existing technology in novel ways), and discontinuous innovation. More generally, across a variety of industries, these superior firms realized 49 percent of their revenues from products developed over the prior five years versus only 11 percent for mediocre performers (Deschamps and Nayak, 1995). There is a burgeoning literature on the competitive importance of innovation and the linkage between innovation and organization renewal across industries and countries (Schoonhoven et al., 1990; Morone, 1993; Hamel and Prahalad, 1994; Burgelman, 1994; Brown and Eisenhardt, 1995b; Henderson and Clark, 1990; Rosenbloom and Christensen, 1994; Utterback, 1994; Jellinek and Schoonhoven, 1990; and Tushman and Anderson, 1986).

Yet with all the attention paid to the importance of innovation and new product development, a curious puzzle should concern reflective managers. Technology and resource-rich firms often fail to compete in the very technologically turbulent environments that they helped create. Consider SSIH, the Swiss watch consortium, and Oticon, the Danish hearing aid firm. Both organizations dominated their respective worldwide markets (SSIH through the 1970s and Oticon through the 1980s), and both developed new technologies that had the capabilities to re-create their markets (e.g., quartz movements and in-the-ear [ITE] volume and tone control). Though SSIH and Oticon had the technology and the resources to innovate, it was smaller, more aggressive firms that initiated new technology in watches and hearing aids. SSIH and Oticon prospered until new industry standards (what we will call dominant designs) destroyed both SSIH's and Oticon's market positions in a matter of a few years.

In both the emergence of quartz watches and ITE hearing aids as dominant designs, it was not new technology that led to the demise of the Swiss or the Danes—indeed, SSIH and Oticon were the technology leaders. Nor was the sudden loss in market share due to lack of financial resources or governmental regulations. Rather, the sudden demise of SSIH and the huge losses at Oticon were rooted in organization complacency and inertia. These pathologies of sustained success led to SSIH's and Oticon's inability to renew themselves through proactively initiating streams of innovation. Innovation streams are patterns of innovations that simultaneously build on and extend prior products (e.g., mechanical watches, behind-the-ear [BTE] hearing aids) *and* destroy those very products that account for a firm's historical success (e.g., quartz watches, ITE hearing aids). These innovation streams shape and reshape markets.

SSIH and Oticon are not unique. The stultifying, innovation-numbing effects of success are a global phenomenon. Consider the recent economic performance of firms listed in Figure 1.1. Each firm on the list, whether American, French, Japanese, Dutch, German, or Swiss, dominated their respective market for years, only to be rocked by economic crisis as their markets shifted. This paradoxical pattern in which winners, with all their competencies and assets, often become losers is found across industries and countries (e.g., Rosenbloom and Christensen, 1994; Henderson and Clark, 1990). It seems that building core competencies and managing through continuous improvement are not sufficient for sustained competitive advantage. Worse, under a remarkably frequent set of conditions, building on core competencies (e.g., the Swiss building on precision mechanics) and engaging in continuous, incremental improvement actually traps the organization in its distinguished past and leads to catastrophic failure as technologies and, in turn, markets shift. Core competencies often turn into core rigidities (Barton, 1992).

Every firm in Figure 1.1, like SSIH or Oticon, was out-innovated by more nimble, foresightful

IBM	Syntex	Smith Corona
Kodak	Philips	Siemans
Sears	Volkswagen	Fuji Xerox
General Motors	SSIH	Zenith TV
	Oticon	

Fig. 1.1. The paradox of success.

(though not more resource-rich) competitors. This success paradox, these competence-based pathologies, is driven by historically constrained managerial action (often inaction) and organizational processes in the context of changing technological and market opportunities, not by the invisible hand of the market nor by governmental or public policy. Thus the troubles at General Motors, IBM, Philips, or Siemens were not rooted in public policy issues, but rather by these firms' inability to either take advantage of technological opportunities, or to directly shape the nature of technological change in their respective markets (like the Swiss and Oticon). These firms were unable to build and extend their existing competencies to develop innovations that would create new markets (as Starkey did with ITE hearing aids) and/or rewrite the competitive rules in existing markets (as Seiko did with qnartz watches).

This success paradox is not deterministic; core competencies need not become core rigidities. Some organizations are capable of moving from strength to strength, extending and/or replacing competencies and proactively moving to shift bases of competition through streams of innovation. These firms are able to develop incremental innovation as well as innovations that alter industry standards, substitute for existing products, and/or reconfigure products to fundamentally different markets. For example, in the watch industry, Seiko was able to not only compete in mechanical watches (the historically dominant technology), but also was willing to experiment with the quartz and tuning fork movements. With this technological experimentation, Seiko managers made the bold, proactive decision to substitute their quartz watch for their existing mechanical watches. The switch to quartz movements led to fundamentally different competitive rules in the watch industry. Similarly, Starkey (the U.S. hearing aid company) was able to move beyond BTE hearing aids to ITE hearing aids by simply reconfiguring existing hearing aid components. This seemingly minor innovation led to a new industry standard (as ITE designs substituted for BTE designs) and different industry rules (focusing on sound quality and fashion).

Seiko and Starkey are not unique. Nokia, Sony, HP, Ericsson, and Motorola are all firms that have been able to shift from today's strength to tomorrow's strength (e.g., Barton, 1992; Jellinek and Schoonhoven, 1990; Foster, 1987; Morone, 1993; Brown and Eisenhardt, 1995b). These organizations are able to develop and migrate competencies snch that old competencies provide a platform for building new, often fundamentally different, competencies. Those firms that are able to sustain competitive advantage over time are able to shape technology cycles through creating streams of innovation. These streams include incremental, competence-enhancing, innovation (e.g., thinner mechanical watches), architectural or configurational innovation (e.g., Starkey's ITE hearing aid), as well as fundamentally new, competence-destroying, innovation (e.g., Seiko's quartz movement substituting for mechanical movements). By actively managing streams of innovation, senior teams increase the probability that their firm will be able to shape industry standards (that provide the assumptions around which incremental innovation occurs), take advantage of fundamentally new markets for existing technology, and proactively introduce substitute products which, as they cannibalize existing products, create new markets and competitive rules (see also Hurst, 1995; Hamel and Prahalad, 1994; Utterback, 1994).

OUR CORE IDEAS

We build on research and practice to develop ways out of these competency traps. We provide concepts and tools in helping managers manage for today's innovation requirements even as they simultaneously build both technical and organizational competencies to develop innovation that will shape tomorrow's competitive requirements. While managers cannot know in advance what innovations will achieve market success, in managing simultaneously for today and tomorrow, managers build organizations that are systematically more "lucky" than the competition. We introduce our core ideas here and provide detail in the next section.

Building on the technology life cycle literature, we introduce the idea of *innovation streams*—patterns of innovation that are required for sustained competitive advantage. Innovation streams focus attention away from innovations in isolation, toward patterns of fundamentally different innovation as a market unfolds. Further, a focns on innovation streams calls attention to products as made up of a set of subsystems, each of which has its own innovation stream. Thus watches are made up of a set of subsystems (e.g., energy source, oscillation device, face, etc.), each of which was transformed between 1970 and 1984. Sustained competitive advantage is gained from managing innovation streams for each subsystem (Abernathy and Clark, 1985; Tushman and Rosenkopf, 1992).

Innovation streams are driven by shifts in the underlying *technology cycle*. Technology cycles call managerial attention to the importance of industry standards (e.g., the quartz movement, Windows operating system, the QWERTY keyboard) as well as technological discontinuities (e.g., batteries replacing springs as the energy source in watches) as critical junctures in a market's evolution. Dominant designs and technological discontinuities are demarcation points between fundamentally different competitive arenas. Dominant designs and technological discontinuities are not technically determined; rather, they are windows of competitive opportunity where managerial action can shape market rules and subsequent innovation patterns (e.g., Tushman and Anderson, 1986; Anderson and Tushman, 1990; Utterback, 1994; Baum and Korn, 1995).

If sustained competitive advantage is built by simultaneously creating fundamentally different types of innovation (e.g., mechanical *and* quartz watches at Seiko, BTE, *and* ITE hearing aids at Starkey), managers must be capable of building and managing organizations that can simultaneously create both incremental and discontinuous innovation. *Ambidextrous organizations* have multiple organization architectures to concurrently nurture these diverse innovation requirements. We link innovation streams to multiple, inconsistent, internally contradictory organization architectures that must co-exist within a single organization (i.e., at Seiko, the development of the quartz watch was done in a different facility, with different managers, roles, structures, and culture than the mechanical watch facility). Such ambidextrous organizations are capable of operating simultaneously for the short and long term, for today and tomorrow, for both incremental and discontinuous innovation. Such dual organizations build in the experimentation, improvisation, and luck associated with small organizations, along with the efficiency, consistency, and reliability associated with larger organizations (e.g., Eisenhardt and Tabrizi, 1995; Imai et al., 1985).

Ambidextrous organizations are, however, inherently unstable. Most often, the older, larger, more traditional units sabotage those more entrepreneurial units—usually today's efficiency (and incremental innovation) kills tomorrow's architectural (e.g., Oticon's inability to initiate the ITE hearing aid) and/or discontinuous innovation (e.g., SSIH's inability to initiate the quartz movement). Given these dynamics, senior management teams must both create the *internal diversity* associated with ambidextrous organizations as well as *provide balance* between the needs of today's innovation demands with that of tomorrow's innovation possibilities.

In such internally inconsistent organizations, the senior management team must provide clear roles and responsibilities for the contrasting units and be a force for integration and balance. A clear, common, shared competitive vision is a powerful tool to bind internally inconsistent units together (e.g., Morone, 1993; Collins and Porras, 1994). Without experimental, entrepreneurial units there can be no future, yet without efficient, consistent units there can be no present. These dualities bring internal conflict and politics. These necessary tensions can only be managed by a senior team that can both build ambidextrous organizations and can articulate a clear, common vision within which these tensions make sense.

Ambidextrous organizations create the intraorganizational diversity that provides senior management with data, insight, and opportunity to take strategic action to proactively shape technology cycles and, in turn, market rules. For example, internal experimentation at Seiko gave senior managers the knowledge to make a choice between further funding mechanical watches and/or shifting to the quartz (or tuning fork) movements. At critical junctures in a market's evolution, particularly at the shaping of industry standards and at technological discontinuities, internal experimentation provides senior managers with alternatives from which those managers can act to proactively shape industry standards (as Seiko and Starkey did), create new markets (e.g., Starkey's move into the fashion market), and/or initiate product substitutes (e.g., Seiko's substituting quartz for mechanical watches).

But such strategic decisions *must be coupled with strategic organization change*. Managers can only rewrite industry rules if they are also willing to rewrite their organization's rules. For example, the proactive innovation moves at both Seiko and Starkey were executed by sweeping changes in strategy, structure, competencies, and processes. Where Seiko and Starkey initiated proactive strategic change coupled with their strategic innovation, SSIH and Oticon were forced to make much more costly and traumatic reactive strategic change.

Proactive strategic innovation and change and proactive moves to rewrite market rules always face entrenched resistance from the status quo. Such consequential decisions are often clouded by the firm's prior success or are made proactively but poorly implemented. Strategic innovation always ruptures stable political equilibria, embedded competencies, cultures, and organization processes. Thus managing innovation streams requires not only buildiug ambidextrous orgauizations, but also organizations capable of *executing systemwide change*, even in the face of prior success. Managing strategic innovation is as much about managing chauge as it is about managing technology.

We discuss, then, developing streams of innovation, building ambidextrous organizations, the role of the senior management team in building and integrating this diversity, and senior management's role in managing large system change associated with strategic innovation. These are all crucial competencies for sustained competitive advantage; for building from today's to tomorrow's competitive strength.

TECHNOLOGY CYCLES AND INNOVATION STREAMS

Technology Cycles. Much is written on the relative importance of incremental versus discontinuous innovation and on the relative importance of market pull versus technology push innovation (e.g., Morone, 1993; Deschamps and Nayak, 1995; Gomory, 1989). In competitive, technology-intensive global markets, competitive advantage can only be built through a combination of different types of innovation—through the creation of not only product snbstitutes, but also architectural innovation as well as through continuous, incremental innovation (Abernathy and Clark, 1985; Iansiti and Clark, 1994; Brown and Eisenhardt, 1995a; Sanderson and Uzumeri, 1995). It is the ability to produce streams of different kinds of innovation that drives sustained competitive advantage. To better understand the structure and flow of innovation streams, we need to understand technology cycles. Clarifying technology cycles helps untangle the relative timing and importance of incremental, architectural, and discontinuous innovation.

Technology cycles are composed of technological discontinuities (i.e., quartz and tuning fork movements in watches) that trigger periods of technological and competitive ferment. These turbulent innovation periods are closed with the emergence of an industry staudard or dominant design (e.g., quartz movement dominated both the mechanical escapement and tuning fork mechanisms) (Tushman and Anderson, 1986; Anderson and Tushman, 1990; and Utterback, 1994). For example, in early radio transmission, continuous wave transmission was a technological discontinuity that threatened to replace spark-gap transmission. Continuous-wave transmission initiated competition not only between continuous-wave transmission and spark-gap transmission, but also between three variants of continuous wave transmission (alternating wave, arc, and vacuum tube transmission) (Aitkeu, 1985). This period of technological ferment led to vacuum tube transmission as the dominant design in radio transmission (Rosenkopf and Tushman, 1994). The emergence of a dominant design ushers in a period of incremental as well as architectural technological change, which at some point, is broken by the next substitute product (i.e., electronic typewriters replaced electric typewriters, which had previously replaced mechanical typewriters). This subsequent technological discontinuity then triggers the next wave of technological variation, selection, and retention (see Figure 1.2).

Technology cycles are seen most directly in simple, or nonassembled products (e.g., skis, tennis racquets, glass, chemicals). For example, in crop fungicides, Ciba-Geigy's propiconazol (Tilt) was a new chemical entity that challenged Bayer's and BASF's products. Propiconazol triggered competition between chemical entities as well as between a vast number of formulations within propiconazol. Ciba eventually created its EC 250 version, which became the industry standard in crop fungicides. More recently, Ciba Crop Protection division has initiated several product substitutes (including genetically engineered seeds) to cannibalize and replace propiconazol. These fundamentally new crop protection products will initiate the next technology cycle in the crop protection market.

In more complex assembled products (e.g., watches) and systems (e.g., radio, voice mail), these technology cycles apply at the subsystem level. For example, watches are assembled products made up

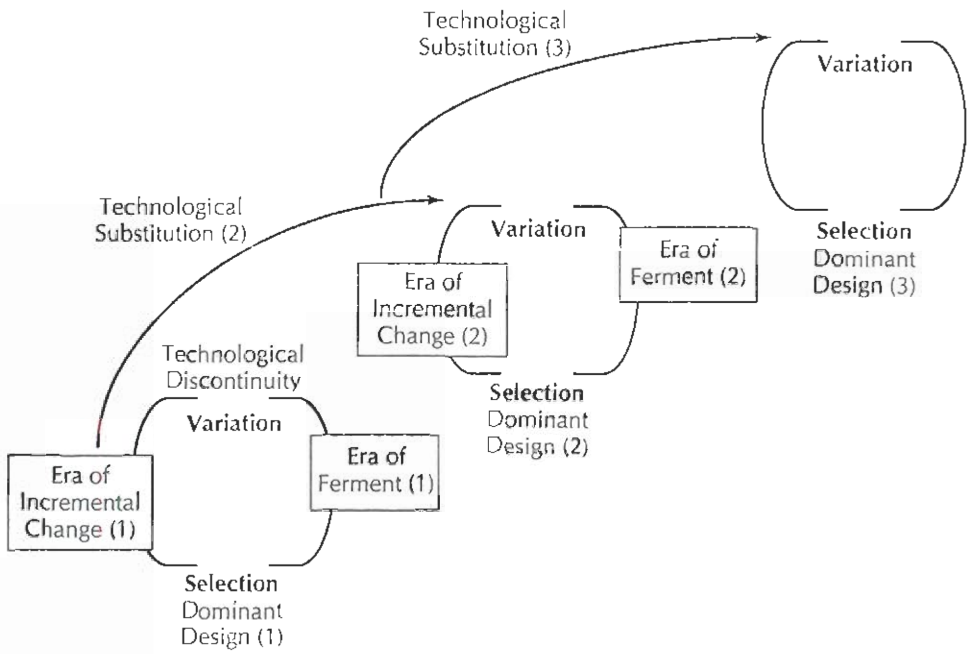


Fig. 1.2. Technology cycles over time.

of at least four subsystems: energy source, oscillation device, transmission, and display. Each of these subsystems has its own technology cycle. For example, the pin-lever escapement became the dominant design in watch oscillation in the late nineteenth century. Escapements became better and better through incremental changes in the same fundamental design until the late 1960s. Between 1968 and 1972, escapements were threatened by both tuning fork and quartz oscillation. This period of technological competition between escapements, tuning fork and quartz movement, ended with the emergence of quartz oscillation as the dominant design in the oscillating subsystem (see Landes, 1983). As with mechanical escapements, the emergence of quartz movements as the dominant design led, in turn, to numerous incremental improvements in the quartz movement and sharp decreases in innovation in tuning fork and escapement oscillatiou devices.

Note that in the watch industry, between 1970 and 1985, every subsystem of the watch, from energy source to face, was transformed through its own technology cycle of technical variation, selection of a dominant design, and subsequent period of incremental change. While watches are a unique product, they do provide a generic illustration of complex products as made up of interconnected subsystems, each of which has its own technology cycle. Further, each subsystem shifts iu relative strategic importance as the industry evolves. For example, where oscillation was the key strategic battlefield through the early 1970s, once the quartz movement became the dominant design, the locus of strategic innovation shifted to the face, energy, and transmission subsystems. Similar dynamics of subsystem and linkage technology cycles have been documented in a variety of industries (see Tushman and Rosenkopf, 1992; Henderson and Clark, 1990; Henderson, 1995; Noble, 1984; Hughes, 1983; Van de Ven and Garud, 1994; David, 1985; Morone, 1993).

Technology cycles are made up of alternating periods of technological variation, competitive selection, and retention (or convergence). *Technological discontinuities* initiate technology cycles; they are rare, unpredictable events triggered by scientific advance (e.g., battery technology for watches) or through the unique combination of existing technology (e.g., Sony's Walkman, or continuous aim gunfire). Technological discontinuities rupture existing incremental innovation patterns and spawn a period of technological ferment in which competing technological variants vie for market acceptance (e.g., the competition between tuning fork, quartz, and escapement oscillation, or the competition between MAC, UNIX, OS/2, and Windows operating systems). Such periods of technological ferment involve competition between existing versus new technology (e.g., escapement versus tuning fork and quartz; AC versus DC power systems) as well as competition between variants of the new technology (e.g., 60, 120, 240 cycles AC power). These eras of ferment are confusing, uncertain, and costly to customers, suppliers, vendors, and regulatory agencies (see Figure 1.3).

From such periods of variation, or eras of technological ferment, a *single dominant design* emerges. For example, numerical control dominated record playback in numerical control machine tools, 60 cycle AC power dominated 120 cycle power (in the United States), fan beam dominated pencil beam in CT scanning, high strength magnetic fields dominated low strength fields in MRI imaging, VHS format dominated Beta in VCR, and Windows format dominated MAC, UNIX, and OS/2 in operating systems (Noble, 1984; Morone, 1993; Hughes, 1983; Cusumano et al., 1992). Absent strong patents, competing firms switch to the new standard or risk getting locked out of the market (see Figure 1.4).

How do dominant designs emerge? Except for the most simple, nonassembled products (e.g., cement), the closing on a dominant design is not technologically driven. Rather, dominant designs emerge out of competition between alternative technological trajectories initiated and pushed by competitors, alliance groups, and governmental regulators, each with their own political, social, and economic agendas. Because no technology can dominate on all possible dimensions of merit, the closing on a dominant design takes place not through the invisible hand of the market and not through natural selection, but through competi-

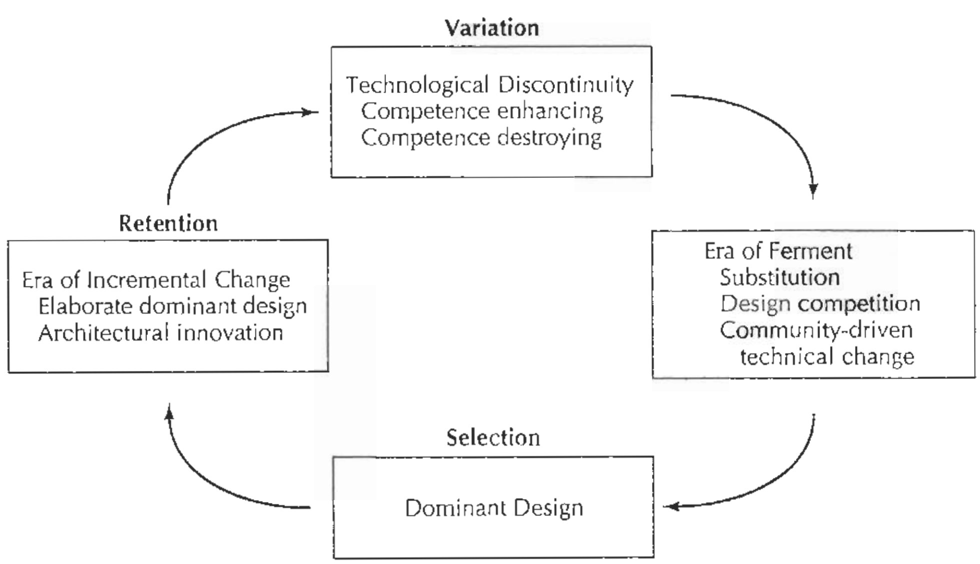


Fig. 1.3. A technology cycle.

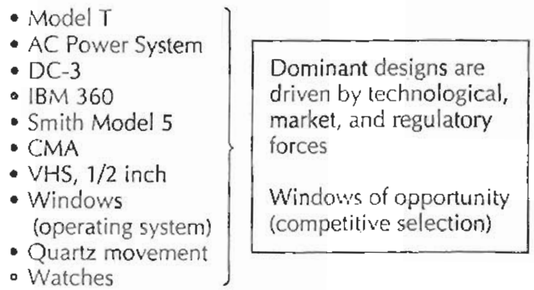


Fig. 1.4. Examples of dominant designs.

tive/political competition between the alternative technological variants (Henderson, 1995; Hughes, 1983; Noble, 1984; Baum and Korn, 1995; Tushman and Rosenkopf, 1992).

Dominant designs are watershed events in a technology cycle. Where before the dominant design technology progress is driven by competition between alternative technological trajectories, after the dominant design subsequent technological change is driven by the logic of the selected technology itself (see Figure 1.3). The closing on a dominant design shifts product innovation from major product variation to major process innovation and, in turn, to incremental innovation—building, extending, and continuously improving the dominant design (Abernathy and Utterback, 1978). These periods of incremental innovation lead to profound advances in the now standard product (Hollander, 1965; Florida and Kenney, 1990; Tushman and Anderson, 1986). In contrast, the consequences of betting on the "wrong" design are devastating—particularly if that subsystem is a core subsystem (e.g., IBM's losing control of the microprocessor and operating system of PCs to Intel and Microsoft, respectively).

The emergence of a dominant design also permits the development of product platforms and families (Morone, 1993; Sanderson and Uzumeri, 1994; Meyer and Utterback, 1993). A product family is a set of products built from the same fundamental technology platform. These product families share traits, architecture, components, and interface standards. For example, once Sony closed on the WM-20 platform for its Walkman, it was then able to generate more than thirty incremental versions within the same family. Indeed, over a ten-year period, Sony was able to develop four Walkman product families and over 160 incremental versions of those four fundamental families. Such sustained attention to technological discontinuities at the subsystem level (e.g., flat motor and miniature battery), closing on a few standard platforms, and incremental product proliferation helped Sony control industry standards in its product class and outperform Japanese, American, and European competitors (Sanderson and Uzumeri, 1994).

These periods of incremental innovation are, in turn, broken by subsequent technological discontinuities. *Subsequent product or process technological discontinuities* trigger the next cycle of technological variation, selection, and incremental change (see Figures 1.2 and 1.5). For example, in Ciba's Crop Protection Division, Wolfgang Samo hosted the development of fundamentally new chemical fungicides (competence enhancing), as well as biologically engineered seeds (competence destroying). Samo's point of view was that if Ciba did not substitute for its own successful product line, BASF or Bayer would. Creating substitute products and/or processes and cannibalizing one's product line prior to the competition is an impor-

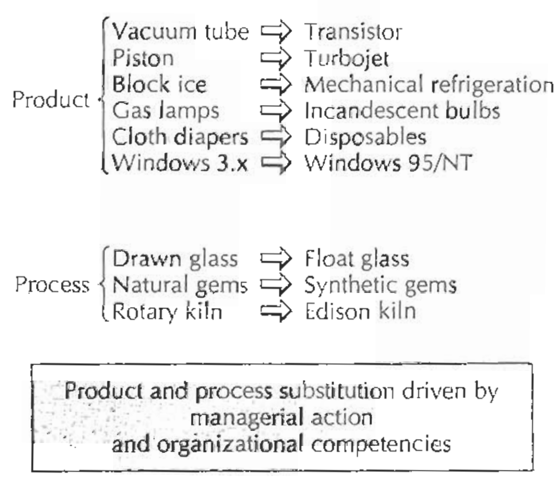


Fig. 1.5. Product process substitution.

tant source of competitive advantage (Foster, 1986; Iansiti and Clark, 1994; and Morone, 1993).

Finally, architectural innovations are those innovations that affect how a given set of core subsystems are linked together (Henderson and Clark, 1990). These innovations (i.e., smaller fans, watches, hearing aids, or disk drives) reconfigure the same core technology and take the reconfigured product to fundamentally different markets (e.g., Starkey's move into the fashion hearing aid market, Honda's early move to smaller motorcycles, or the migration of disk drive technology from mainframes to personal computers). While architectural innovation may be technologically simple and associated with substantial economic returns, these shifts are frequently missed by incumbent firms (Henderson and Clark, 1990; Henderson, 1995; Rosenbloom and Christensen, 1994).

Technology cycles are composed of periods of technological ferment, the closing on a dominant design, leading to a period of incremental innovation, which is, in turn, broken by the next technological discontinuity and subsequent technology cycle and/or by the next architectural innovation. For example, in typewriters, the Smith Model 5, the IBM Selectric, and word processing reflect the march of dominant designs over an eighty year period (Utterback, 1994). These cycles apply for both product subsystems as well as for linking technologies. These patterns hold across product classes—the only difference between high (e.g., minicomputer and low (e.g., cement) technological industries is the length of time between the closing on a standard and the subsequent discontinuity. Thus from an innovation perspective, what lies behind the familiar S-shaped product life cycle curve are fundamentally different innovation requirements. Eras of ferment require discontinuous product variants and dominant designs are associated with fundamental process innovation, while eras of incremental change are associated with streams of incremental and architectural innovation (Utterback, 1994; Anderson and Tushman, 1994) (see Figure 1.2).

Innovation Streams. Given the nature of technology cycles, the roots of sustained competitive advantage lie in a firm's ability to proactively initiate incremental, architectural, as well as discontinuous innovation. Management must develop the diverse competencies and organizational capabilities to shape and take advantage of dominant designs (e.g., Windows versus OS/2), shape architectural innovation, as well as introduce substitute products prior to the competition (e.g., Windows 95 versus IBM's WARP). Thus the route to sustained competitive advantage is not through either incremental (market driven) innovation or through discontinuous (technology driven) innovation, but through the capabilities of producing streams of innovation over time (see Figure 1.6).

Innovation streams have very different characteristics over time and require diverse and shifting technological, marketing and manufacturing, and organizational capabilities. Opening a new product class (e.g., crop protection products, CT scanners, or portable phones) is the most turbulent, whitewater part of the innovation stream. This era of ferment is associated with major product variation as producers offer their variants to new markets (e.g., multiple early crop protection agents, multiple CT variants, and multiple portable phone variants). These multiple variants are produced within firms as well as between firms (e.g., Ciba versus BASF; Motorola versus Ericsson; and EMI versus GE) (see Figure 1.6).

This turbulent, uncertain period is closed with the emergence of a dominant design. The closing on a dominant design is associated with the innovation stream shifting away from product variation toward major process innovation. Dominant designs result from firms betting on a product variant and then initiating major process innovation to drive down cost (e.g., Motorola's 1983 commercial portable phone, IBM's 360 design; GE's fan beam CT technology; or Ciba's bet on EC-250. The success of these bets can only be in retrospect.

After the closing on an industry standard, the innovation stream is more stable; there ensues a relatively long period of incremental and/or generational innovation (e.g., Sony's four Walkman generations and 160 incremental innovations) (see Figure 1.6). Periods of incremental innovation lead,

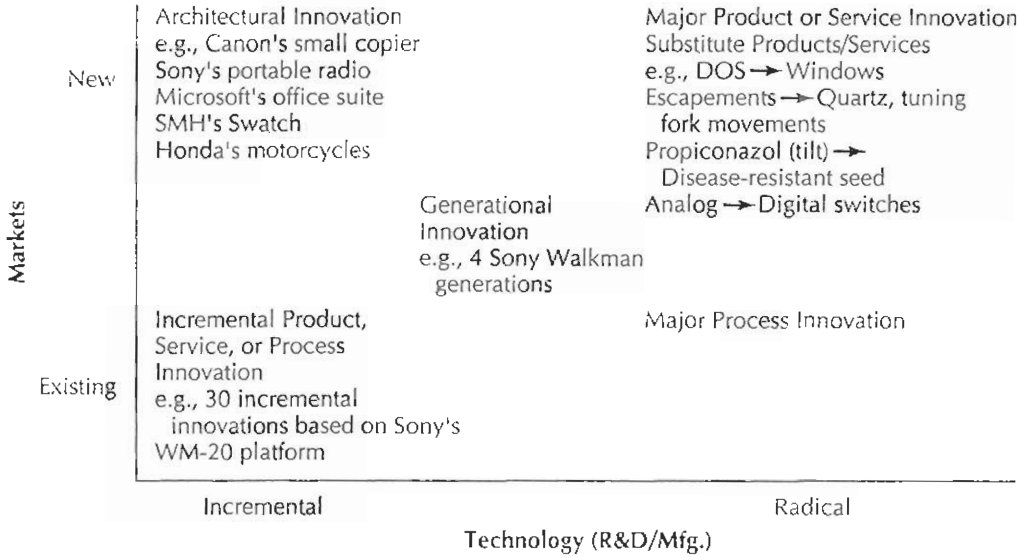


Fig. 1.6. Innovation streams.

in turn, to either architectural innovation, taking the standard product to fundamentally new markets (e.g., Starkey taking its ITE hearing aids to more fashion-conscious European markets) and/or to developing product substitutes (e.g., Seiko developing the quartz and tnning fork movements or Ciba developing fungicide-resistant seeds). Product substitutes initiate the next cycle of technological variation, dominant design, and era of incremental change.

Innovation streams direct managerial attention away from a particular innovation or a particular innovation orientation (e.g., market push versus technology pull; incremental versus discontinnous), toward streams of contrasting innovations that must be produced within a business unit over time (e.g., within Ciba's Crop Protection division). Innovation streams call attention to maintaining control over core product subsystems, and to dominant designs, architectural innovation, and product substitution as windows of opportunity where proactive managerial action can shape technological evolution and, in turn, bases of competition. Finally, through such proactive management of technology cycles and innovation streams managers have the opportunity to build on mature technologies (e.g., mechanical movements), which provide the base from which the new technology (e.g., quartz movement) can emerge. Thus the dying technology provides the compost, which allows its own seeds, its own variants, to grow and thrive.

BUILDING AMBIDEXTROUS ORGANIZATIONS: ORGANIZATION ARCHITECTURES AND INNOVATION STREAMS

Technology cycles and the nature of innovation streams indicate that sustained competitive advantage is built on simultaneously operating in mnltiple modes: managing incremental, architectural, as well as discontinuous innovation, managing for short-term efficiency and long-term innovation. If sustained competitive advantage is built via creating different types of innovation contemporaneously, managers must be capable of building organizations that can handle such innovative and strategic diversity (e.g., Rosenbloom and Christensen, 1994; Iansiti and Clark, 1994;

Morone, 1993). Executive teams must be capable of building ambidextrous organizations; organizations with multiple, internally inconsistent architectures (Weick, 1979; Burgelman, 1994).

Much is written on strategic intent and industry foresight (e.g., Hamel and Prahalad, 1994). While a firm's strategic intent and innovation strategy may be well articulated, the ability of the senior team to develop organizational capabilities to actually execute strategy may be the more scarce strategic capability. For example, where disk drive mannfacturers knew the different markets for their disk drive technologies, very few incnmbents were able to take their technologies across the mainframe, mini-computer, and PC computer markets (Rosenbloom and Christensen, 1994). Management teams must be able not only to craft strategic intents, but also to directly couple their strategic intents to organizational architectures (Tushman and O'Reilly, iu press).

Managers have hardware and software tools in building organizational architectures (Nadler and Tushman, 1989, in press; Nadler et al., 1992). Hardware tools include organization structures, systems, and rewards as well as work processes and flows. Software tools include the firm's human resonrce capabilities, its cultnre, norms, and social networks, as well as the characteristics and competencies of the senior team (see Figure 1.7). Anchored by the unit's strategy, objectives, aud vision, management teams build social and technical systems, internally congruent organization arrangements, human resources, culture, and work processes that can execute the unit's strategic intent more rapidly than the competition (Tushman and O'Reilly, in press). Performance shortfalls are

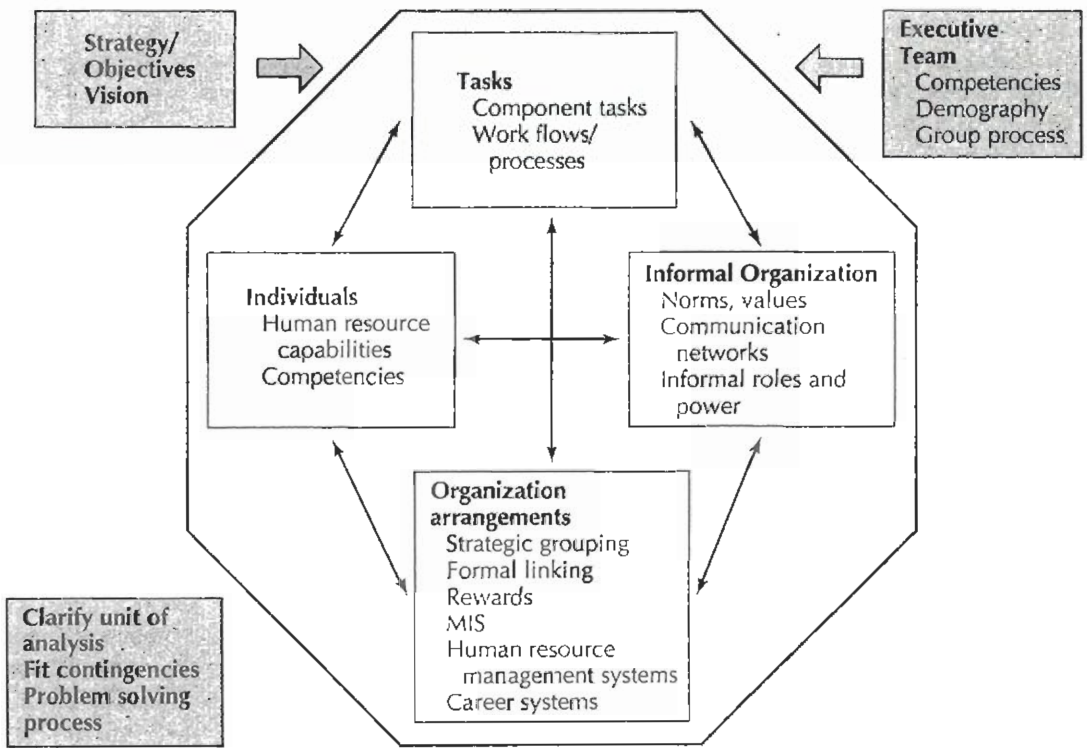


Fig. 1.7. Organization architecture: A congruence model of organizations. (*Source:* Adapted from Tushman and Nadler, 1994.)

caused either by internal inconsistencies within the technical and social systems and/or by inappropriate strategies.

Organizational architectures for incremental innovation are fundamentally different than for discontinuous innovation. What organizational architecture is appropriate for incremental innovation? Continuous, incremental improvement in both the product and associated processes, and high volume throughput associated with incremental innovation requires organizations with relatively structured roles and responsibilities, centralized procedures, efficiency-oriented cultures, highly engineered work processes, strong manufacturing and sales capabilities, and demographically more homogeneous, older, and experienced human resources (Tushman and Nadler, 1986; Eisenhardt and Tabrizi, 1995). These efficiency-oriented units celebrate continuous improvement and the elimination of variability and have relatively short time horizons. These units have well-developed knowledge systems, have learned through continuous, incremental improvement, are highly inertial, and often have glorious histories (e.g., SSIH, U.S. Steel, IBM, Philips) (see Figure 1.8). Neither discontinuous nor architectural innovation is a natural outcome of efficiency-oriented organizations (e.g., Henderson and Clark, 1990).

What organizational architecture is appropriate for discoutinuous innovation? In dramatic contrast to incremental innovation, discontinuous innovation emerges from entrepreneurial, skunkworks types of organizations. These entrepreneurial units are relatively small, have loose, decentralized structures, experimental cultures, loose, jumbled work processes, strong entrepreneurial and technical competencies, and a relatively young and heterogeneous human resource profile. These entrepreneurial units generate the experiments, the failures, and the variation from which the senior team can learn about the future. These units explicitly build new experience bases, knowledge systems, and networks to break from the organization's history. They generate the variants from which the senior team can make bets on both possible dominant designs and technological discontinuities (see Figure 1.8) (Burgelman, 1994; Nonaka, 1988; Eisenhardt and Tabrizi, 1995). In contrast to the larger, more mature, efficiency-oriented units, these small entrepreneurial units are inefficient, rarely profitable, and have no established histories.

Architectural innovation does not require different core technologies, but rather takes existing technologies and links these technologies in novel ways. For example, Starkey took extant hearing aid technology, repackaged this technology into a smaller space, and created the ITE hearing aid market. Architectural innovation is not built on new

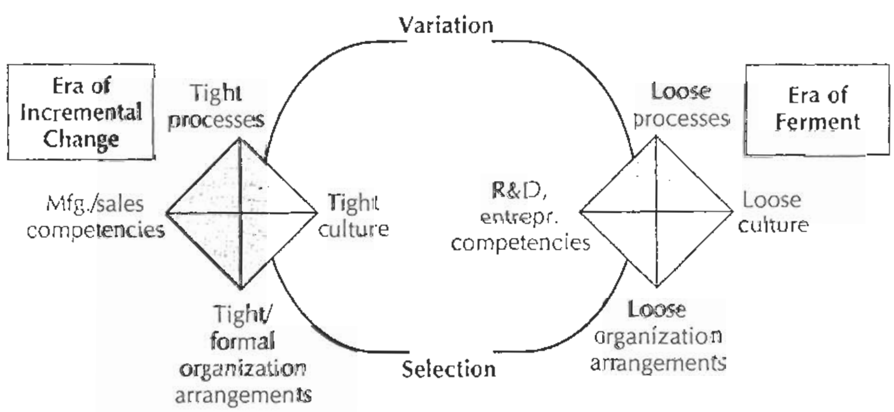


Fig. 1.8. Organization architectures and technology cycles.

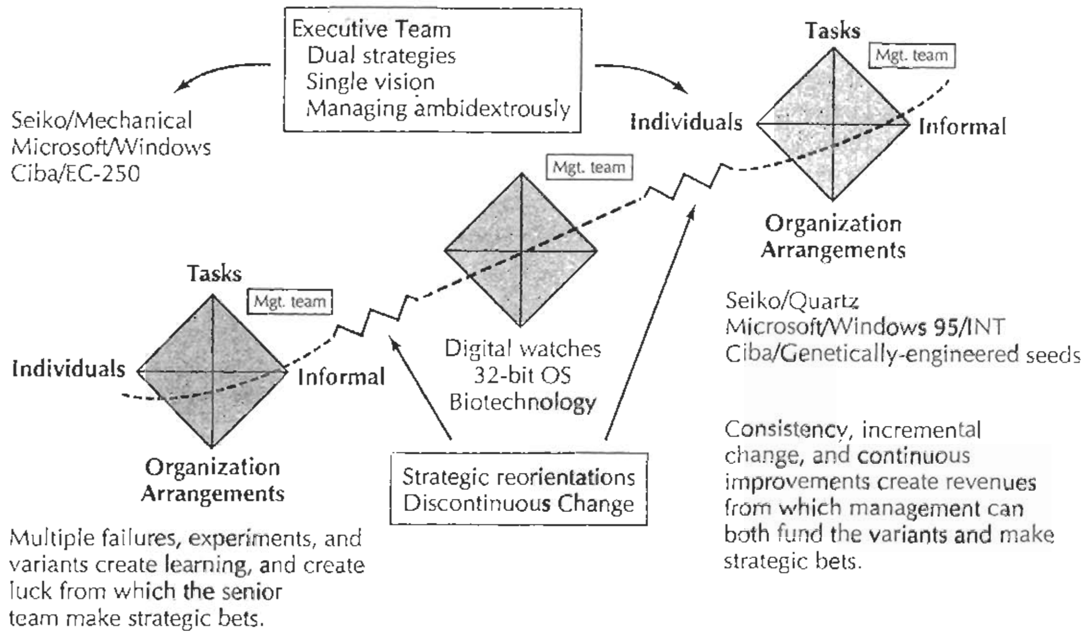


Fig. 1.9. Organization architectures. Managing ambidextrously: Creating both consistency and luck.

technical breakthroughs, but rather on integrating competencies from both efficiency and entrepreneurial units and in building distinct organizational architectures to bring this new product to new markets (see also Iansiti and Clark's [1994] discussion of supercomputers and Brown and Eisenhardt's [1995b] discussion of computers and workstations). While technologically simple, architectural innovations are often not initiated by incumbents because of the difficulties in developing organizational linking competencies (e.g., Henderson and Clark, 1990; Henderson, 1995).

Innovation streams require organizations to be simultaneously capable of producing incremental, architectural, as well as discontinuous, innovations. But these different innovation types require fundamentally different organization architectures within a simple business unit. For example, Samo at Ciba Crop Protection cannot afford an either/or innovation strategy. He must continue to support incremental innovation in his mature propiconazol product even as he works to develop fundamental product substitutes (e.g., a biologically engineered seed that will never get ill). Samo's challenge is to build an ambidextrous Crop Protection division—a division that is capable of simultaneously hosting fundamentally different organizational architectures (see Figure 1.9). More generally, the senior management's challenge is to build into a single organization multiple integrated organizational architectures. A single organization must host multiple cultures, structures, processes, and human resource capabilities required to be incrementally innovative (new and improved propiconazol) while at the same time create products that might cannibalize the existing product line (e.g., a new seed).

Ambidextrous organizations have built-in contradictions. These cultural, structural, demographic, and process contradictions are necessary if the organization is to be able to produce streams of innovations. Yet these necessary internal contradictions create conflict and dissensus between the different organization units—between those historically profitable, large, efficient, older, cashgenerating units versus the young, entrepreneurial, risky, cash-absorbing units. Because the power, resources, and traditions of organizations are usually anchored in the older, more traditional units, these units usually work to ignore, trample, or otherwise kill the entrepreneurial units.

The certainty of today's incremental advance often works to destroy the potential of tomorrow's architectural and/or discontinuous advance. For example, the Swiss watch producers had all the quartz and tuning fork technology, but chose to destroy those variants and reinvest in mechanical movements. Oticon had both the idea and technology to move into ITE hearing aids, yet it was incapable of innovating until after Starkey had taken this new market. Similarly, IBM and Xerox had the software, mieroprocessor, and imaging competencies within their firms, but chose to reinvest in mainframe and reprographic technology. Given these inertial, defensive, and political dynamics, the management team must not only protect and legitimize the entrepreneurial units, but also keep these units physically, culturally, and structurally separate from those more mature units (e.g., Cooper and Smith, 1992). But this is difficult; in industry after industry, those major firms, those with the competencies to unleash architectural and/or discontinuous innovation, chose to close off internally generated learning and reinvest in their past; core capabilities over and over become core rigidities (Barton, 1992; Utterback, 1994; Kearns and Nadler, 1992; Foster, 1986; Morone, 1993; Hamel and Prahalad, 1994; and Rosenbloom and Christensen, 1994).

BUILDING AMBIDEXTROUS MANAGEMENT TEAMS AND MANAGING STRATEGIC INNOVATION AND CHANGE

Ambidextrous Management Teams. As innovation streams require internally inconsistent organization architectures, it is the senior management team that must balance today's incremental innovation demands with tomorrow's architectural and discontinuous innovation requirements. The senior team must be able to host and reconcile the dual, paradoxical organization requirements of ambidextrous organizations (Quinn and Cameron, 1988). This internal diversity provides the senior team with knowledge and competencies for both today and tomorrow. These insights provide the learning from which managers can develop foresight to alter industry rules.

Yet ambidextrous organizations are unstable. Senior teams must themselves have the internal heterogeneity and competencies to handle these dual innovation demands (e.g., Ancona and Nadler, 1992; Eisenhardt, 1989; Nonaka, 1988; and Eisenhardt and Tabrizi, 1995). The senior team must be able to host the diverse roles, structures, processes, and cultures of the different organization architectures. For example, Samo at Ciba Crop Protection must encourage one manager to continue to champion and innovate in propiconazol even as Samo encourages another prodnct champion to develop a substitute for propiconazol (see also De Castro's dual strategy at Data general [Kidder, 1982]). These senior teams must provide the push, drive, and direction for incremental innovation even as they dream and challenge another piece of the organization to re-create the future.

Senior management must not only create and manage highly differentiated organizations (that is, organizations for both today and tomorrow), but also highly integrated organizations (Iansiti and Clark, 1994; Lawrence and Lorsch, 1967). Beyond organization differentiation, the senior team must provide the formal rules, regulations, roles, and rewards as well as informal networks, norms, and values to achieve integration (Brown and Eisenhardt, 1995a). But formal integration is insufficient. The senior team can also use competitive visions to achieve organization integration in ambidextrous organizations (see Collins and Porras, 1994). Clear, simple visions, like Motorola's "best in class in portable communication devices," or Ciba's "most dominant crop protection competitor, worldwide," permit the senior team to celebrate incremental innovation and efficiency along with discontinuous change, experimentation, and learning through failure. It is only through such clarity of vision that the senior team can support and embrace internally contradictory organization architectures associated with ambidextrous organizations and still be consistent.

Competitive vision provides the strategic axiom from which management teams can balance the paradoxical requirements of strategic innovation. Clear, emotionally engaging visions create a point of clarity within which organizations can be simultaneously incremental and discontinuous, short-term and long-term, efficient and innovative, centralized and decentralized (Collins and Porras, 1994; Nonaka, 1988; and Imai et al., 1985). Thus in the mid-1980s, Seymour Cray and John Rollwagen's vision for Cray was "we make the world's fastest computer." Within such a vision, Cray was able to hold onto its classic Cray Strategy of custom-made supercomputers as well as move into high-volume, low-cost supercomputers. An image of a management team managing streams of innovation is, then, that of a juggler juggling multiple balls simultaneously. As with jugglers, most management teams can do one thing well (i.e., juggle one ball). It is the rare management team that can articulate a clear, compelling vision and simultaneously host multiple organization architectures (i.e., multiple balls) without sounding confused or, worse, hypocritical.

Strategic Innovation and Discontinuous Organization Change. With ambidextrous organizations managers build into their business units the capability of managing in multiple time frames; managing simultaneously for today's innovation requirements and tomorrow's innovation possibilities. Entrepreneurial units provide learning-by-doing data, insight, and luck regarding possible dominant designs, architectural innovation and product substitution. These entrepreneurial units provide a range of experiences from which the senior team can learn about possible futures. In contrast, more mature units drive sustained incremental innovation and more short-term learning. With these diverse types of innovation and organization learning taking place within the firm, the senior management team has the raw data from which to make strategic decisions—when to try and create a dominant design (and what product variant to bet on), when to initiate an architectural innovation, and/or when to introduce a product substitute that might cannibalize the existing product line (McGrath et al., 1992). For example, Samo and his senior team at Ciba Crop Protection must understand the options for both continued development of propiconazol and the genetically engineered seed, and make a decision when, where, and how to initiate the substitute product.

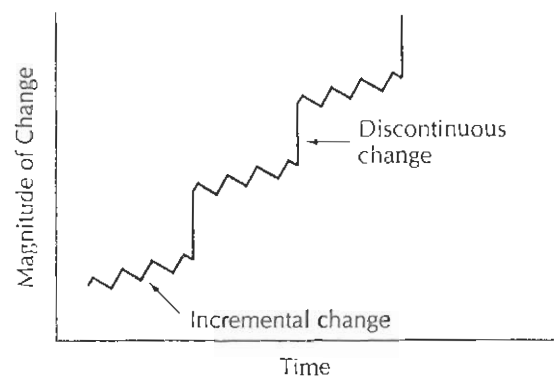
Dominant designs, architectural innovation, and product substitution events are windows of strategic opportunity in which managerial action can shape and/or reinvent a product class (Tushman and Rosenkopf, 1992; Hamel and Prahalad, 1994). During eras of ferment, management can move to shape the closing on a dominant design; during eras of incremental change, management can act to substitute for its existing product line. For example, IBM's bet on the 360 mainframe series fundamentally shaped the evolution of that product class just as Seiko's move on the quartz movement fundamentally changed the watch product class. While one can know dominant designs and successful product substitutes ex post facto (e.g., VHS over Beta, quartz over escapements), management teams cannot know the "right" decisions on either dominant designs or substitution events ex ante. Yet through building dual organizational capabilities, the management team maximizes the probability that it will have both the "luck" and the expertise from which to make industry shaping decisions proactively versus reactively (e.g., Peters, 1990; Cohen and Levinthal, 1990). Further, while "correct" strategic innovation bets can only be known in retrospect, managerial action within the firm, with collaborators, alliance partners, and governmental agencies can affect the ultimate closing on an industry standard and/or the success of the product substitute (see Teece, 1987; McGrath et al., 1992).

At the closing on a dominant design, innovation within the firm shifts from major product variation to major process innovation and, in turn, to sustained incremental innovation (Abernathy, 1978; Abernathy and Clark, 1985). At product substitution events and for architectural innovation, strategic innovation shifts from incremental innovation to major product or process innovation. As strategic innovation requirements shift at these junctures, so too must the dominant organizational capabilities. Those organizational architectures, structures, roles, cultures, processes, and competencies so appropriate during eras of ferment are no longer appropriate during eras of incremental change, just as those organizational architectures so appropriate during eras of incremental change are no longer appropriate during eras of ferment (see Figure 1.9). For example, in Ciba's Crop Protection division, the organization architecture used so effectively to produce, promote, and sell mature propiconazol will have to be completely reconfigured if Samo's team decides to introduce the disease-resistant seed.

At these strategic junctures, shifts in a firm's innovation stream can only be executed with concurrent, discontinuous organization change. Sharp shifts in the innovation stream can only be executed through sharp organizational shifts. Managers can only attempt to rewrite their industry's rules if they are willing to rewrite their organization's rules (Anderson and Tushman, 1994; Romanelli and Tushman, 1994; Utterback, 1994; and Morone, 1993). For example, IBM's 360 decision in mainframes was coupled with sweeping shifts in IBM's structure, controls, systems, and culture. Bold strategic moves and/or great technology left uncoupled to revised organizational capabilities leads to underperformance. For example, Sony's superior Beta technology format was not able to counter JVC's combination of an adequate VHS technology coupled with brilliant organizational capabilities and strategic alliances (e.g., with Matsushita, Cusumano et al., 1992; Teece, 1987). Shifts in innovation streams must, then, be tightly coupled with shifts in organization structures, competencies, cultures, and processes (see also Rosenbloom and Christensen, 1994). Strategic innovation is as much rooted in organizatiou architectures as it is in technological prowess.

Strategic innovation requires fundamentally different organizational architectures. Yet the need for discontinuous organization change runs headlong into internal forces for inertia. Patterns in organization evolution across industries and countries suggest that these contrasting forces cannot be adjudicated through incremental organization change. Incremental change benefits today's organization even as it stunts the move to tomorrow's organizatiou (Tushman et al., 1986; Romanelli and Tushman, 1994). Organization renewal aud shifts iu innovatiou streams can be executed through strategic reorientation—discontinuous and concurrent shifts in strategy, structure, competencies and processes. These frame-breaking organizational changes are often initiated by revised senior teams (see Romanelli and Tushman, 1994; Miller, 1990; and Meyer et al., 1990).

Our model of business unit evolution is one of long periods of incremental change punctuated by discontinuous, frame-breaking, organization change (see Figure 1.10). Organizations can move from today's strength to tomorrow's strength through strategic reorientations. Strategic reorientations are coupled to shifts in the innovation stream; coupled to moves on a dominant design, architectural innovation, and product substitution.



- Organization evolution: Periods of incremental change punctuated by discontinuous change.
- Executive team succession often associated with discontinuous change.
- Managing discontinuous change fundamentally different than managing incremental change.

Fig. 1.10. Patterns in organization evolution.

For example, the shift to the 360 series at IBM, Seiko's shift to the quartz movement, and Starkey's shift to ITE hearing aids were all coupled with proactive strategic reorientations. If strategic reorientations are not done proactively (as in the IBM 360, Seiko, and Starkey examples), they will have to be done reactively (as with Burroughs in mainframes, SSIH in watches, and Oticon in hearing aids). Reactive reorientations (often called turnarounds) are more risky than proactive reorientations, because they must be implemented under crisis conditions and under considerable time pressure, which hinders the firm's ability to learn (Tushman and O'Reilly, in press; Hamel and Prahalad, 1994; Hurst, 1995; and Rosenbloom and Christensen, 1994).

As innovation streams shift over time, so too must organizational architectures. The management team must develop not only its ability to conceptualize strategic reorientations, but also its ability to execute the strategic changes associated with going from a given present state to a fundamentally different future state (Nadler et al., 1995; Tushman and O'Reilly, in press). The senior team must build its capabilities to manage not only incremental organization change, but also discontinuous organization change (Hurst, 1995).

The management challenge for discontinuous change is fundamentally different from managing incremental change. Discontinuous change must be initiated and directed by the senior team, must be driven by an integrated change agenda, and must be rapidly implemented—driven by the senior team's clear vision and committed actions. These strategic changes are often coupled with shifts in the senior team and within middle management. Further, the management of strategic orientations must attend to the politics of the change, individual resistance to change, and maintaining control during the transition period (Nadler et al., 1995; Tushman and O'Reilly, in press; Nadler and Tushman, 1989). If implemented through incremental change methods, strategic reorientations run the risk of being sabotaged by the politics, structures, and competencies of the status quo (e.g., Virany et al., 1992; Kearns and Nadler, 1992). For example, in Ciba's Crop Protection division, the transition from fundamentally different fungicides to EC-50 (its bet on a dominant design) was executed through sweeping changes in the division and through a new fungicide team. In contrast, breakthrough innovation at Xerox in the late 1970s and early 1980s was not coupled with corresponding organizational shifts. The politics of stability held Xerox hostage to its past (Smith and Alexander, 1990; Kearns and Nadler, 1992).

MANAGING AMBIDEXTROUSLY: EMBRACING CONTRADICTIONS AND ORGANIZATION LEARNING

Managing streams of innovation is about managing dualities: managing and embracing not efficiency versus innovation, not tactical versus strategic, not large versus small, not today versus tomorrow, but efficiency *and* innovation, tactical *and* strategic, large *and* small, today *and* tomorrow. Managing innovation streams is about consistency and control as well as variability, learning by doing, and the creation of luck. It is the crucial role of the senior team to embrace these contradictions and take advantage of the tensions and synergies that emerge from juggling multiple competencies simultaneously (see also Hurst, 1995; Collins and Porras, 1994. It is the role of vision and strategy to bind these dualities, these paradoxical requirements together. Only through clarity of vision can these multiple contradictions be reconciled and integrated and innovation streams executed.

While success seems to be hazardous, it is possible to get and stay on top. While relatively rare, Corning's success in ceramics, Ciba's success in crop protection, and Motorola's success in mobile phones indicate that it is possible to build sustained competitive advantage and to move from strength to strength (Morone, 1993; Brown and Eisenhardt, 1995b). We have emphasized building executive teams and leadership throughout the organization that can simultaneously manage the strategies, structures, competencies, work processes, and cultures for both short-term efficiency as well as create the conditions for tomorrow's strategic innovation. Thus we have talked not about organization structure or culture for innovation, but about structures and cultures for strategic innovation and change. Organizations with dual capabilities are able to maximize the probability that the firm will be more effective in the short term *and* be able to make proactive and informed strategic bets. It is through such dual, ambidextrous organizations that managers can build the capabilities to be most effective in the short run and create the conditions to initiate and implement strategic innovation. It is through such dual organizational capabilities that managers create both the expertise and luck from which they can shape their firm's future.

Sustained competitive advantage is about senior team and organization learning. The senior team must learn from its own behavior and from the organization's responses to their actions. First order learning is based on continuous improvement, consistency, balance, and congruence between task demands and people, organization arrangements, and culture. This learning mode is about getting better and better in the execution of today's strategy. Second order learning, in contrast, is dedicated to destroying today's business, cannibalizing today's product, and moving out from the organization's past. This learning mode is created by building experimentation and variants into the system. These variants, created by contrasting structures, people, and cultures, generate the data and expertise from which managers can then make strategic innovation bets. These strategic innovation bets must then be implemented.

Managing strategic innovation is about managerial action; action driven by clear strategies, objectives, and vision, action disciplined by systematic data gathering, and action that eventually renews the organization by proactive strategic innovation and change. Strategic innovation is not about quick fixes or fashionable techniques—it is not about re-engineering, speed, strategic intent, decentralization, or empowerment. It is about a comprehensive approach to managerial problem solving and action based on an integrative problem solving framework, and an understanding of the linkages between innovation streams, executive teams, and organization evolution.

Finally, strategic innovation is about implementation. Strategy, vision, and innovation are empty words—indeed, the world is full of great visions, strategies, technologies, and innovations that never were implemented, or were implemented well after the competition. As vision, strategy, and innovation streams are really in their execution, we have highlighted the importance of effectively managing strategic change. As innovation always is associated with organizational changes, managers must focus on managing change within their units, change across their organizations, as well as with organizations outside the focal organization. We have coupled the ideas of managing innovation streams with the dynamics of managing change—managing politics, control, and individual resistance to change.

Even if periods of incremental change do contain the seeds of their own destruction, organizations can move from strength to strength. Through proactive strategic change, senior teams can manage the rhythm by which as each strength dies it gives way to the next. Prior organizational competencies provide a platform so that the next phase of an organization's evolution does not start from ground zero. Organizations can then renew themselves through a series of proactive strategic reorientations anchored by a common vision. These strategic reorientations are coupled to bets on dominant designs, architectural innovation, and/or product substitution. Like a dying vine, the prior period of incremental change provides the compost for its own seeds, its own variants, to thrive in the subsequent period of incremental change.

Our approach to strategic innovation evokes several images of managers involved in the management of innovation streams. Managers can be seen as simultaneously organization architects/social engineers, as network builders/politicians, as well as artists/jugglers (see Figure 1.11). The manager as engineer/architect focuses on social engineering, using the tools of strategy, structures, human resource competencies, and cultures to build

The Manager As:	Role:
☐ Architect/Engineer	☐ Building fit, consistency and congruence of structures, human resources, and cultures to execute critical tasks in service of strategy, objectives, and vision. ☐ Continuous improvement.
☐ Politician/Network Builder	☐ Managing strategic change by building networks and shaping coalitions down, across, ups, and outside the manger's unit.
☐ Artist	☐ Building in contradictory strategies, structures, competencies, and cultures in service of both incremental and discontinous innovation, as well as integrating these contradictions through vision and strategy.

Fig. 1.11. Managerial metaphors in managing strategic innovation and change.

robust organizations to get today's work and tomorrow's innovation accomplished. Yet at junctures in a product class, shifts in the innovation stream must be coupled with discontinuous organization change. These change requirements run counter to the dynamic conservatism found in successful firms. Therefore, the second managerial image focuses on the manager as a network builder and politician, building cliques and coalitious in service of innovation and change. Finally, we have focused on managers as artists—building in the tensions and contradictions of managing both for today as well as for tomorrow, even as these managerial artists integrate these contradictions into an internally consistent whole. These multiple managerial images and associated competencies seem to be necessary to manage innovation streams; these managerial and, in turn, organizational competencies seem to be necessary to achieve and sustain competitive advantage in turbulent product classes.

REFERENCES

Abernathy, W.J. *The Productivity Dilemma*. Baltimore: Johns Hopkins Press, 1978.

Abernathy, W. and Clark, K. "Innovation: Mapping the Winds of Creative Destruction." *Research Policy*, 1985. 14, 3–22.

Abernathy, W. and J. Utterback. "Patterns of Industrial Innovation." *Technology Review*, 1978, 2, 40–47.

Aitken, H. *The Continuous Wave*. Princeton: Princeton University Press, 1985.

Ancona, D. and D. Nadler. "Top Hats and Executive Teams." *Sloan Management Review*, 1989, 31 (1), 19–28.

Anderson, P. and M. Tushman. "Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change." *Administrative Science Quarterly*, 1990, 35, 604–633.

Barton, L. "Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. *Strategic Management Journal*, 1992, 13, 111–125.

Baum, J. and H. Korn. "Dominant Designs and Population Dynamics in Telecommunications Services." *Social Science Research*, 1995, 24 (2), 97–135.

Brown, S. and K. Eisenhardt. "Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry." Administrative Science Quarterly [ASQ] 1995a, 40, 84–110.

Brown, S. and K. Eisenhardt. "Product Development: Past Research, Present Findings and Future Directions." *Academy of Management Review*, 1995b, 20 (2).

Burgelman, R. "Fading Memories: A Process Theory of Strategic Business Exit." *Administrative Science Quarterly*, 1994.

Cohen, W. and D. Levinthal. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly*, 1990, 35 (1), 128–152.

Collins, J. and J. Porras. *Built to Last*. New York: Harper Business, 1994.

Cooper, A. and C. Smith. "How Established Firms Respond to Threatening Technologies." *Academy of Management Executive*, 1992, 6 (2), 55–70.

Cusumano, M., Y. Mylonadis, and R. Rosenbloom.

"Strategic Maneuvering and Mass Market Dynamics: The Triumph of VHS Over Beta." *Business History Review*, 1992, 66, 51–94.

David, P. "Clio and the Economics of Qwerty." *American Economic Review*, 1985, 75 (2), 332–337.

Deschamps, J. and P. Nayak. *Product Juggernauts*. Cambridge, Mass.: Harvard Business School Press, 1995.

Eisenhardt, K. "Making Fast Strategic Decisions in High Velocity Environments." *Academy of Management Journal*, 1989, 32 (3), 543–576.

Eisenhardt, K. and B. Tabrizi. "Acceleration Adaptive Processes." *Administrative Science Quarterly*, 1995, 40 (1), 84–110.

Florida, R. and Kenney, M. *The Breakthrough Illusion*. New York: Basic Books, 1990.

Foster, R. *Innovation: The Attacker's Advantage*. New York: Summit Books, 1986.

Gersick, C. "Pacing Strategic Change: The Case of New Ventures." *Academy of Management Journal*, 1994, 37 (1), 9–45.

Gomory, R. and R. Schmitt. "Science and Product." *Science*, 1988, 240, 1131–1204.

Hamel, G. and C. Prahalad. *Competing for the Future*. Cambridge, Mass.: Harvard Business School Press, 1994.

Henderson, R. "Of Life Cycles Real and Imaginary: The Unexpectedly Long Old Age of Optical Lithography." *Research Policy*, 1995, 24 (4), 631–643.

Henderson, R. and K. Clark. "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms." *Administrative Science Quarterly*, 1990, 35 (1), 9–30.

Hollander, S. *Sources of Efficiency*. Cambridge, Mass.: MIT Press, 1965.

Hughes, T. *Networks of Power*. Baltimore: Johns Hopkins Press, 1983.

Hurst, D. *Crisis and Renewal*. Cambridge, Mass.: Harvard Business School Press, 1995.

Iansiti, M. and K. Clark. "Integration and Dynamic Capability." *Industrial and Corporation Change*, 1994, 3 (3), 557–605.

Imai, K., I. Nonaka, and H. Takeuchi. "Managing the New Product Development Process: How Japanese Firms Learn and Unlearn." In Clark, K. et al., (eds.), *The Uneasy Alliance*. Cambridge, Mass.: Harvard Business School Press, 1985.

Jellinek, M. and C. Schoonhoven. *The Innovation Marathon*. Cambridge, Mass.: Blackwell, 1990.

Kearns, D. and D. Nadler. *Prophets in the Dark*. New York: Harper, 1992.

Kidder, T. *The Soul of a New Machine*. Boston: Little, Brown, 1982.

Landes, D. *Revolution in Time*. Cambridge, Mass.: Harvard University Press, 1983.

Lawrence, P. and J. Lorsch. *Organizations and Environments*. Cambridge, Mass.: Harvard Business School Press, 1967.

McGrath, R., I. MacMillan and M. Tushman. "The Role of Executive Team Actions in Shaping Dominant Designs: Towards Shaping Technological Progress." *Strategic Management Journal*, 1992, 13, 137–161.

Meyer, A., G. Brooks, and J. Goes. "Environmental Jolts and Industry Revolutions." *Strategic Management Journal*, 1990, 11.

Meyer, M. and J. Utterback. "Product Family and the Dynamics of Core Capability." *Sloan Management Review*, 1993, 34 (3).

Miller, D. *The Icarus Paradox: How Exceptional Companies Bring about Their Own Downfall*. New York: Harper, 1990.

Morone, J. *Winning in High Tech Markets*. Cambridge, Mass.: Harvard Business School Press, 1993.

Nadler, D., M. Gerstein, and R. Shaw. *Organization Architecture*. San Francisco: Jossey-Bass, 1992.

Nadler, D., R. Shaw, and E. Walton. *Discontinuous Change*. San Francisco: Jossey-Bass, 1995.

Nadler, D. and M. Tushman. *Strategic Organization Design*. Glenville, Ill: Scott Foresman, 1988.

Noble, D. *Forces of Production*. New York: Alfred Knopf, 1984.

Nonaka, I. "Creating Organizational Order Out of Chaos: Self Renewal in Japanese Firms." *California Management Review*, 1988, 30 (3), 57–73.

Peters, T. "Get Innovative or Get Dead." *California Management Review*, 1990, Pt. 1, 33 (1), 9–26; Pt. 2, 33 (2), 9–23.

Quinn, R. and K. Cameron. *Paradox and Transformation*. Cambridge, Mass.: Ballinger Publications, 1988.

Romanelli, E. and M. L. Tushman, "Organizational Transformation as Punctuated Equilibrium: An Empirical Test." *Academy of Management Journal*, 1994, 37, 1141–1166.

Rosenbloom, D. and C. Christensen. "Technological Discontinuities, Organization Capabilities, and Strategic Commitments." *Industry and Corporate Change*, 1994.

Rosenkopf, L. and M. Tushman. "The Coevolution of Technology and Organization." In Baum, J. and J. Singh (eds.), *Evolutionary Dynamics of Organizations*. New York: Oxford University Press, 1994.

Sanderson, S. and V. Uzumeri. "Managing Product Families." *Research Policy*, 1995, 24 (5), 761–782.

Schoonhoven, K., K. Eisenhardt, and K. Lyman. "Speeding Products to Market." *Administrative Science Quarterly*, 1990, 35 (1), 177–207.

Smith, D. and R. Alexander. *Fumbling the Future*. New York: Harper, 1990.

Teece, D. "Profiting from Technological Innovation." In D. Teece (ed.), *The Competitive Challenge*. New York: Harper & Row, 1987.

Teece, D. and G. Pisano. "Dynamic Capabilities of Firms." *Industry and Corporate Change*, 1994, 3, 537.

Tushman, M. and P. Anderson. "Technological Discontinuities and Organization Environments." *Administrative Science Quarterly*, 1986, 31, 439–465.

Tushman, M. L. and D. Nadler. "Organizing for Innovation." *California Management Review*, 1986, 28 (3), 74–92.

Tushman, M., W. Newman, and E. Romanelli. "Convergence and Upheaval: Managing the Unsteady Pace of Organizational Evolution." *California Management Review*, 1986, 29 (1), 29–44.

Tushman, M. and C. O'Reilly. *Evolution and Revolution: Mastering the Dynamics of Innovation and Change*. Cambridge, Mass.: Harvard Business School Press, in press.

Tushman, M. and E. Romanelli. "Organization Evolution: A Metamorphosis Model of Convergence and Reorientation." In L. Cummings and B. Staw (eds.), *Research in Organizational Behavior*, vol. 7. Greenwich, Conn.: JAI Press, 1985, 171–222.

Tushman, M. and L. Rosenkopf. "On the Organizational Determinants of Technological Change: Towards a Sociology of Technological Evolution." In B. Staw and L. Cummings (eds.), *Research in Organization Behavior*, vol. 14. Greenwich, Conn.: JAI Press, 1992, 311–347.

Utterback, J. *Mastering the Dynamics of Innovation*. Cambridge, Mass.: Harvard Business School Press, 1994.

Van de Ven, A. and R. Garud. "The Coevolution of Technical and Institutional Events in the Development of an Innovation." In Baum, J. and J. Singh (eds.), *Evolutionary Dynamics of Organizations*. New York: Oxford University Press, 1994.

Virany, B., M. Tushman, and E. Romanelli. "Executive Succession and Organization Outcomes in Turbulent Environments." *Organization Science*, 1992, 3 (1), 72–91.

Weick, K. *The Social Psychology of Organizing*. Reading, Mass.: Addison-Wesley, 1979.