

## Chapter 14. Innovation<sup>1</sup>

By Kathryn A. Baker

If defined broadly, innovation can be seen as the business of science organizations. However, like most of the organizational literature, the innovation literature has largely focused on innovation in private sector business organizations. This literature may, nonetheless, have insights that can be used by the science organizations, both private and public. First, although science organizations need to innovate, they have not necessarily taken the lead in systematically studying how organizational and environmental factors can best promote innovation. Also science organizations in both the private and public sector are under greater pressure not only to generate innovative science but also to function as a business. For example, there is greater emphasis on commercializing scientific discoveries, having a solid and well-designed portfolio of science programs and projects that help the organization adapt to external changes in funding priorities, and demonstrating results and favorable cost/benefit ratios. This innovation literature may provide insights into balancing innovation with business realities. While the literature on innovation in private sector organizations may be a source of useful insights, it may also be the case that studying science organizations could provide critical insights into how to promote and sustain innovation in private sector business organizations. Public science organizations should consider playing a lead role in promoting strategies for encouraging and sustaining innovation and developing a true innovation competency.

### **Overview**

The literature on innovation has a long history. The early research on innovation tended to address the organization's ability to respond and adapt to external and/or internal changes (Burns and Stalker 1961; Hull and Hage 1982). Subsequent work on innovation stressed more pro-active innovation and distinguished between types of innovation. Emphasis was on the organization's ability to promote both process and product innovation, regardless of an immediate need for change (Kanter 1988). The organization's ability to promote process and product innovation has been argued to be no longer sufficient and a third type of innovation has been introduced in the literature—called strategy innovation by some and business concept innovation by others. This type of innovation stresses the growing need for today's organizations to proactively address challenges of the future by undertaking radical innovation that will transform their environments and the marketplace (Hamel and Prahalad 1994; Hamel 1996). Organizations can no longer remain successful by merely adapting to external change and/or innovating in terms of products/services.

The concept of innovation has become more complicated in other ways as well. The first major scholar to address this topic, Joseph Schumpeter, defined innovation as encompassing the entire process, starting from a kernel of an idea continuing through all the steps to reach a marketable product that changes the economy. Now, there is not only a distinction between three major types of innovation (process; product/service; and business concept) but current scholars now distinguish levels of innovation (incremental to radical and sustaining versus discontinuous), no

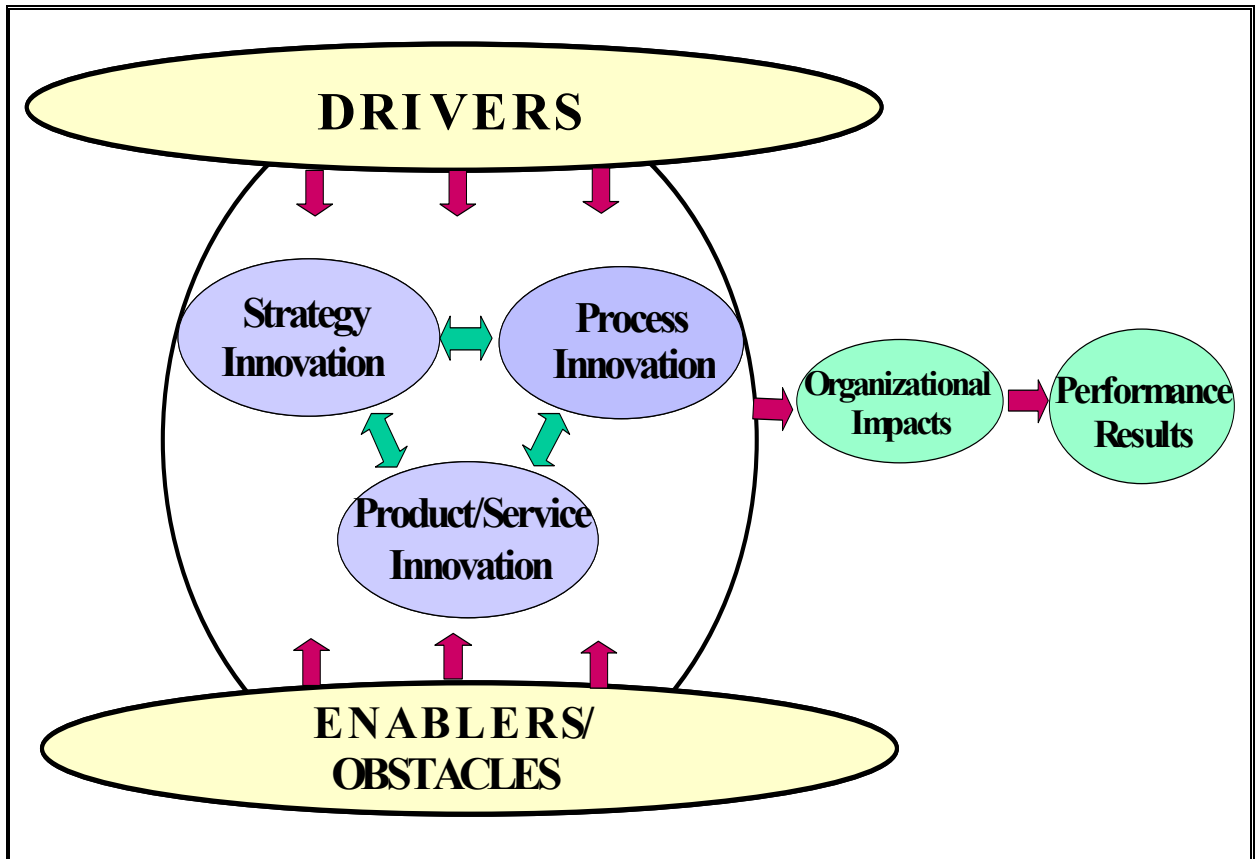
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<sup>1</sup> Related chapters include: Strategy; Change Management; Competencies; Organizational Alliances, Partnerships and Networks; Creativity.

longer restricting the term to major innovations that change the economy. Finally innovation is no longer restricted to the process of creating something new from beginning to end but can include the capacity to quickly adopt externally created innovations that may be of benefit to the organization.

### ***A Framework for Understanding Organizational Innovation***

Figure 1 provides a general framework for understanding organizational innovation.



**Figure 1. Framework of Organizational Innovation.**

This framework identifies the following major questions considered by those interested in organizational innovation:

- ◆ What is innovation?
- ◆ What are the drivers of innovation?
- ◆ What can enable or hinder innovation?
- ◆ What are the results of innovation—the organizational impacts as well as the desired and actual performance results?

## **What is Innovation?**

There are three types of innovation (process, product/service, and strategy) each of which can vary from incremental to radical and from sustaining to discontinuous. There are also important relations between these types of innovation. For example, a strategy innovation may necessitate process, and/or product innovations.

### *Levels of Innovation*

As the term broadened, innovations were seen as ranging from *incremental* to *radical*. This distinction primarily focused on the extent of newness. An innovation can be new within a particular context or new in terms of the overall marketplace of ideas. Similarly, it can be a new twist on an old theme or a radically novel idea. This distinction did not, however, clearly differentiate between newness and impact. In terms of impact, the effect of an innovation can range from: (1) contributing to fairly small improvements to products or to the way things are done, (2) causing a fundamental transformation in the resulting products or services and/or the process technology of an entire industry, or (3) transforming the market place and/or the economy as a whole.

Christensen (1997) advanced the concept of innovation by disentangling the attributes of newness and impact. Because radically new innovations do not always have a significant impact, he differentiates between *sustaining* versus *discontinuous* innovations. Sustaining innovations improve the performance of established products or services. Discontinuous innovations bring to market very different products or services that typically undermine established products and services in the particular market sector. An example of a discontinuous innovation is steel minimills (while the product was not significantly changed, a change in the production process led to a drastic change in prices, firms, and markets). A discontinuous innovation does not always have greater utility; it may, in fact, result in a product that under-performs established products. The reason for this is that the momentum of on-going sustaining innovations can push product and service functionality beyond what many customers may actually require (in other words, the established products and services eventually overshoot a large segment of their market). He advises companies in all industries to be continually attuned to a potentially discontinuous innovation that could cause their demise if they do not quickly adapt and adjust to the fundamentally changing situation.

### *Types of Innovation*

There are three main types of innovation (*process*, *product/service*, and *strategy*), each of which can vary in the degree of newness (*incremental* to *radical*) and impact (*sustaining* versus *discontinuous*).

### Process Innovation

Process innovation became an important topic with the rise of the quality and continuous improvement movements and, then again, with the more recent attention directed at change management, organizational learning and knowledge management. Corporations today, at least

in the developed world, are reaching the limits of incremental process improvement.<sup>2</sup> Some have argued that what is needed today is radical process innovation. Hammer and Champy (1994) introduced the concept of *radical reengineering* based on their assertion that for companies to achieve maximum efficiency and effectiveness requires radical process reengineering of the organization and its processes. Because processes lag far behind what is possible given technological advancement, it is not possible to achieve the necessary transformation through incrementalism.

The argument for radical reengineering seemed plausible and many organizations undertook large scale reengineering efforts. The results, however, have been mixed. Many organizations spent a great deal of time and money for little pay-off (Carter 1999). There are several competing explanations for these failures, including an explanation proposed by one of the initial advocates. Champy (1996) suggests that management has often been a barrier and that successful reengineering of the corporation requires that management itself be radically reengineered. Others suggest that organizations are often not capable of changing as much and as quickly as radical reengineering encourages and that transition management has not been sufficiently addressed (Feldman 1999). There have been two main problems with reengineering: (1) an ambitious model of the reengineered corporation without a sufficiently detailed and realistic plan of how to manage current operations while transitioning to the new model and (2) a lack of the sustained effort needed to ensure success. In addition, as Carter (1999) notes, downsizing has too often posed as reengineering and, not surprisingly, downsizing tends to have short-term and limited benefits. The clear lesson is that radical engineering to be successful must be done with great care and that balance and caution must be exercised.

Discontinuous process innovation can originate outside the industry and/or may be more or less serendipitous. Thus, in addition to intentional process improvement and reengineering, companies must take care to monitor and have the ability to quickly adapt to potential innovations that could affect how they currently operate.

## Product/Service Innovation

Incremental product/service innovation is oriented toward improving the features and functionality of existing products and services. Radical product/service innovation is oriented toward creating wholly new products and/or services. Product life cycles, in particular, have become shorter and shorter, causing business survival to depend on new product development and, increasingly, on the speed of innovation in order to develop and bring new products to market faster than the competition (Jonash and Sommerlatte 1999). Organizations must direct greater attention to new product development, while maintaining and improving their existing products. Discontinuous products and services are increasingly likely with ever-faster new product/service development. Organizations must be constantly on the lookout for discontinuous new products and/or services.

Although product/service innovation and process innovation are not the same thing, they are often interconnected. For example, process innovation may be required to support product or service

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<sup>2</sup> Many American and British companies have reached the point of diminishing returns in their cost-cutting and efficiency programs. In 1999, the average operating margin for the non-financial services companies in the S&P 500 was 15.7%, the same as 5 years earlier. Indeed, between 1994 and 1999, the average operating margin for these companies never varied by more than 1.3 percentage points (Hamel 2000).

innovations. Also, it has been argued that organizational processes and structures oriented to incremental product innovation are not the same as those needed to foster and facilitate new product development. The current wisdom it is necessary to separate these activities and to introduce wholly new process innovations that will help promote and speed-up radical product innovation.

### Strategy or Business Concept Innovation

It is, of course, possible to incrementally improve one's business strategy but Hamel (1996, 2000) contends that radical business concept innovation is now paramount. He claims that the current environment is hostile to industry incumbents and hospitable to industry revolutionaries. The fortifications that protected the industrial oligarchy have crumbled under the weight of deregulation, technological upheaval, globalization, and social change. What is now required to ensure organizational success is to continually revolutionize the basic organizational strategy, which progressively typically requires:

- ◆ Radically reconceiving products and services, not just developing new products and services
- ◆ Redefining market space
- ◆ Redrawing industry boundaries.

If radical business concept innovation is successful in accomplishing these objectives, it is by definition discontinuous.

### ***Drivers of Innovation***

The primary drivers of innovation include:

- ◆ Financial pressures to decrease costs, increase efficiency, do more with less
- ◆ Increased competition
- ◆ Shorter product life cycles
- ◆ Value migration
- ◆ Stricter regulations
- ◆ Industry and community needs for sustainable development
- ◆ Increased demand for accountability
- ◆ Community and social expectations and pressures (giving back to the community, doing good, etc.)
- ◆ Demographic, social, and market changes
- ◆ Rising customer expectations regarding service and quality
- ◆ Greater availability of potentially useful new technologies coupled with the need to keep up or exceed the competition in applying these new technologies
- ◆ The changing economy.

Although cost reduction has been a major driver of innovation, other drivers are also important. Regulatory drivers have become more important in the last several decades. In addition, companies increasingly feel they must promote their image and this has become a major driver of environmental and sustainable development innovations. A good image can help promote both

customer loyalty and a company's growth strategy. As noted above, Hamel (1996, 2000) sees important recent change in both (a) the drivers of innovation and (b) the importance of radical business concept innovation for organization survival. Basically, he argues that a dramatic change in the overall economy has occurred and that this economic environment no longer protects established mainstream businesses. He further argues that organizations must develop an innovation competency if they are to survive: radical business concept innovation must become a core component of this competency.<sup>3</sup>

### ***Enablers and Obstacles to Innovation***

The presence of innovation drivers and/or the need to innovate will not necessarily result in innovation. Innovation is difficult, particularly radical and/or discontinuous innovation. Companies have reengineered their core business processes for efficiency. They now need to reinvent their core business processes for innovation in order to accelerate the production and pay-off of radical ideas. In other words, the capacity to innovate, especially to produce radical and discontinuous innovations, is seen by an increasing number of scholars and practitioners as the new competitive competency of organizations. While some argue that innovation cannot be managed – that it just happens – most researchers and theorists agree that the organizations can be designed to have a structure, a culture, and processes that are conducive to innovation (Roger and Roger 1976; Kanter 1998; Amabile 1988; Jonash and Sommerlatte 1999; Hamel 2000).

As innovation has become a more pressing concern for companies in almost every sector of the economy, the literature has increasingly explored the factors that enable or hinder an organization's capacity to innovate. Factors have been identified at each of the following levels (see the following text box on *Innovative Capacity* for specifics):

- ◆ Individual
- ◆ Project
- ◆ Organization
- ◆ Environment.

Until very recently, most of the literature addressed enabling or hindering factors as residing at the organizational level or below. Organizational level innovation theory and research emphasized innovation output – new product development and the speed of bringing new products to market. Greater attention is now being directed toward increasing the organization's innovation input capacity – the ability of an organization to continuously absorb, accumulate, and create the new knowledge necessary to spur new ideas. This has been referred to as the “organization as sponge explanation” – the organization must absorb more inputs in order to squeeze out more outputs (Fiol 1996). It has also been referred to as the organization's *absorptive capacity* (Cohen and Levinthal 1990). Absorption refers to environmental scanning to identify new ideas that may be of potential relevance, promoting idea generation among the staff, as well as adopting potentially relevant externally developed innovations. It has also clearly been found that smaller and less hierarchical organizations are more capable of innovations. Some

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<sup>3</sup> Incumbency has never been worth less. Deregulation, the internet, venture capitalists, etc. have changed the economic landscape to make it both more hostile to established firms and more hospitable to new ventures. Only 11 of the S&P top 500 delivered top-quartile shareholder returns for more than 5 years out of the last 10 – not one company achieved top-quartile returns in more than 7 of the last 10 years. Success has become highly transient (Hamel 2000).

large organizations have attempted to foster intrapreneurships within the company but, increasingly, large organizations are creating small entrepreneurial spin-offs to enhance their capacity to innovate. Hamel (2000) offers suggestions for larger firms to become incubators of innovation (internally, externally, and via appropriation) and sees no inherent contradiction in being both a large and an innovating organization (see Chapter 4, “Change Management” for additional discussion of these challenges).

## Innovative Capacity

*The Individual Level:* Factors to look for at the individual level include: employee empowerment and engagement, trust, training, job rotation, and the extent and range of individual networks.

*The Project Level:* Factors to look for at the project level include: a diverse mix of project team members, conversation rules and management, and an initial openness to new ideas and withholding of criticism to a later point in the process. As the speed of innovation is becoming a greater concern, greater attention is being focused on ways to speed up innovation projects. There has also been greater attention directed at differentiating between two critical phases of innovation projects: the fuzzy front-end or Phase I activities and Phase II activities. Phase I activities involve new product conceptualization, analysis, and definition, and currently account for half the new product development cycle time. Phase II activities involve the more typical activities of product design, piloting, production, and early marketing. Some have argued that Phase I activities need to be dealt with separately as they require a different type of project management approach (Bacon et al. 1994).

*The Organizational Level:* Organizations must have effective, efficient, and speedy systems and processes for the following:

- ◆ Environmental scanning, identifying discontinuities, surveying customer needs, encouraging new ideas to be advanced by staff members, and innovation activist and other forms of training.
- ◆ Other means of promoting knowledge absorption and sharing, such as the ability to communicate across organizational boundaries, communities of practice, enterprise level knowledge systems, and problem identification and problem solving processes.
- ◆ Deconstructing the dominant mental models regarding business mission, market scope, relevant products and services, target customers and questioning existing biases regarding the kinds of profit boosters that can be exploited, the core competencies that are most important, pricing strategies, bundling options, and partnering opportunities.
- ◆ Sustained, innovative strategizing and strategy implementation.
- ◆ On-going classification, screening, and prioritization of new ideas.
- ◆ Managing the innovation stream—the number of ideas being pursued at a given time and their developmental stages.
- ◆ Effective innovation project management.
- ◆ Effective innovation utilization, transfer, diffusion—the culmination of innovation is to transfer the innovation to those who will exploit it through successful commercialization and, as needed, promoting its adoption into organizational practice and/or individual life styles.
- ◆ Effective change management.
- ◆ Promoting a broad definition of business boundaries, fluid organizational boundaries, and a wide and open market for ideas/talent.
- ◆ Motivating, rewarding, and recognizing innovation.

This sounds very similar to knowledge management, particularly as the focus has expanded beyond increasing the speed of innovation outputs and recognizes the importance of identifying and capturing new ideas/knowledge. Also, it has been found that smaller and less hierarchical organizations are more capable of innovation. Some large organizations have attempted to foster internal intrapreneurships but, increasingly, they are creating small entrepreneurial spin-offs to enhance their capacity to innovate.

*The Environmental Level:* Factors at the environmental are now getting greater attention. These include: the level of competition and extent of customer options, geographical co-location, inter-organizational associations and communities of practice, partnerships and alliances, the regulatory context, and the extent of customer and stakeholder engagement.

The external environmental context is now receiving greater attention. Previously, the external environment had been considered a given – beyond the control of the organization. However, inter-organizational collaborations have now become a major topic in the innovation literature. The ways organizations can take advantage of the environment to encourage and sustain innovation and the ways they can use innovation to buffer themselves from environmental threats are areas that need to be further developed. The literature on institutionalism can provide a possible basis for linking organizational context and environmental (inter-organizational) context and demonstrating how these factors jointly affect organizational strategic action (either strategic conformance or innovation). In the past, institutional theory has been more oriented to explaining organizational similarity (isomorphism) and stability than opportunity for organizational innovation and change. New institutional theory is beginning to address the issue of strategic innovation.

Hamel (2000) suggests that an innovation competency requires both an internal and external organizational perspective. To develop an innovation competency, the organization must:

1. *Have a fluid notion of organizational boundaries and an open market for talent.* It is not necessary to create all innovations internally. Partnerships can be a useful strategy to promote innovation. Also, in addition to development, acquisition can be an effective innovation strategy.
2. *Transform organizational strategy.* Typical strategic planning is often antithetical to promoting radically innovative business models and strategies. Innovation cannot be held to a scheduled strategic planning timeline; it should be on-going. Also, strategy should not be restricted to the same set of top level decision-makers. Innovative strategy does not necessarily come from the top but too often not a word about contributing strategically appears in the performance criteria for anyone below the level of senior executive. Finally, strategy tools can only do so much. IRR forecasts and EVA calculations may be somewhat helpful but thinking about the possibilities is the most important component. Thinking about how big the thing could become and what the obstacles might be and how these can be addressed and constructing a convincing story is the most important part of strategy.
3. *Create an open market for capital investment and rewards.* Strategic thinking must not only be encouraged but also sponsored and rewarded. Just as wealth-generating strategies do not come from the strategic planning process, they do not necessarily come from serendipity or a single visionary (such as Bill Gates-Microsoft, Ted Turner-CNN, Anita Roddick-The Body Shop, Andy Grove-Intell, Jeff Bezos-Amazon.com, Howard Schultz-Starbucks, Mickey Dresler-The Gap, Michael Dell-Dell Computer, Pierre Omidyar-eBay.com). An organization must motivate strategic thinking and be able to quickly assess, select, and support potentially useful innovations. When innovative ideas do not succeed, staff members and sponsors should not be sanctioned in any way. On the other hand, it is very important to allow staff to share in the rewards when an idea does pay-off.
4. *Manage the risk.* Strategy should not be monolithic; it should be sufficiently varied to allow for organizational agility and flexibility. Remember that most innovation ideas will not pan out, so don't think big in terms of funding any one innovative idea. The strategy should be to fund a number of ideas. Low-risk experimentation is key—invest in many ventures but start out small. Although most new ventures will fail, important learning can be acquired from each. Project risk must be distinguished from portfolio risk—the risk of any new project will be high but if there are enough innovation projects, the portfolio risk will be manageable.



5. *Create a culture and a structure that promotes innovation.* Having an elastic business definition helps to ward against protectionist instincts. Senior executives should be directed to spend a significant amount of their time looking for opportunities outside the boundaries of the business they are managing. Deconstruct the dominant mental models regarding business mission, market scope, relevant products and services, target customers and question existing biases regarding the kinds of profit boosters that can be exploited, the core competencies that are most important, pricing strategies, bundling options, and partnering opportunities. Open up innovation opportunities to all staff and engage customers, suppliers, competitors, and complementary organizations to develop new approaches to generating new wealth. Cellular division to promote smaller, independent unit; de-mergers; divestitures; spin-offs; and an EcoNet model that encourages cooperation and collaboration across organizational entities as needed can all help promote innovation.

The degree to which an organization is perceived to be innovative varies. Being innovative does not only refer to the process of creating a new product from the beginning to the end; it can also refer to the capacity of the organization to quickly adopt externally developed innovations. However, companies that wait until new innovations have been widely implemented and have a proven track record are not typically considered innovative. Light (1998) notes that the “whatever is new to us” is the prevailing use of the term in organizations that do not necessarily see themselves as innovation leaders, while “something that significantly changes the marketplace” is more likely to be the standard for highly innovating organizations.

<b><i>How Innovative Is Your Company?</i></b>
Does your company merely keep up with the competition or is it seen as an innovation leader?
Does your company focus on creating new innovations or does it typically adopt useful innovations that have been created elsewhere?
Does your company adequately involve the workforce in identifying and/or creating potentially useful innovations?
Does your company work with customers and others to identify and/or create potentially useful innovations?
Does your company look at innovation possibilities across processes, products and services, and business concepts/strategies?
Has your company introduced fairly radical as well as incremental innovations in each of these areas?
Does your company adequately scan for potentially threatening discontinuous innovations?
Does your company address the need to implement strategies that will help it quickly adapt and respond to potentially threatening discontinuous innovations?
Does your company attempt to create potentially discontinuous innovations?
Does your company treat innovation as a core competency and continually improve and expand its capacity to innovate?

### ***Organizational Impacts and Desired Performance Results***

Indubitably organizational innovations will cause some level of change but the extent and effect of this change is no longer a given. In Schumpeter’s original sense of this term, an innovation – by definition – had a substantial economic impact. An innovation was something that changed the market place in a profound way. The innovating organization was, thus, likely to become the new market leader and to gain an immense advantage over its competitors. With the broadening of the term to include small to radical innovations, sustaining as well as discontinuous innovations, and the capacity to create as well as to quickly adopt new technologies, the impact of innovation is no longer a definitional issue. The impact of innovations has become an empirical

question. Innovations are likely to cause various organizational impacts (organizational changes, challenges, and issues) but they may or may not bring about the desired performance results, such as effectiveness, efficiency, cost savings, customer value, or a transformation of the market place. Although it is easy to find successful innovations that have increased a company's efficiency, improved its products, contributed to customer loyalty, and even transformed the market place, there are also many cases where innovating organizations fail to reap such benefits.

It is exceedingly difficult to estimate the overall pay-off for being innovative. In spite of all the attention being directed at innovation, it is not clear how much or what kinds of innovation are most advantageous. Nor is it clear how necessary and/or sufficient innovation is to ensure one's survival or competitive advantage. One cannot merely look for examples of successful innovations. Success stories are well publicized and easy to find, but information on failed innovations is more difficult to obtain. What is needed to determine the overall pay-off for being innovative are systematic data on the costs and benefits of innovation for organizations in different industrial sectors. It would also be useful to be able to distinguish between different categories and levels of innovation. These kind of systematic data are difficult to obtain but research suggests some partial, albeit inconclusive, answers to the question of overall pay-off.

### Positive Evidence

In recent years, big claims have been made for the importance of innovation to organizations' economic success. In *The Innovation Premium* (1999), Jonash and Sommerlatte, two top Arthur D. Little consultants, conclude that:

Wall Street places a higher value on innovation than on any other approach to generating bottom- and top-line growth...more than a change in leadership, more than a merger or acquisition, more than a renewed commitment to cost reduction... (p. xi).

Their survey of Wall Street analysts found that:

- ◆ 95% of these analysts report that more innovative companies enjoy a share-price premium over less innovative counterparts.
- ◆ 90% think that the importance of innovation has increased significantly over the last ten years.
- ◆ More than 70% report that innovation is a key driver of how the market values companies.

Further, using *Fortune* magazine's rankings of companies by innovation over the last 15 years, they found that innovation rankings correlated with shareholder return – companies in the top 20% of *Fortune*'s ratings enjoyed double the shareholder returns of the other companies in their industries. In addition, 84% of senior management respondents in their 700-company, world-wide study reported that innovation was now a significant strategic issue for their businesses.

### Less Positive and Even Negative Evidence

There is also evidence that points to the negative side of innovation. One researcher concluded that, during the 1980s, American corporations wasted billions of dollars on failed attempts to innovate (Jensen 1993). In fact, there is evidence that it takes as many as 3,000 raw ideas to produce one commercial success (Steven and Burley 1997). This suggests that it is very difficult

for a company to be good at innovation and that, as Hamel (2000) claims, companies need to focus on developing innovation as a core competency. But there are some indications that even those companies that are good at innovation may experience problems in the long run. Christensen (1997) notes that great companies that have sustained innovation over a long period of time can, and do, fail. He refers to this as the *innovator's dilemma*, which is the title of his insightful book. As he explains, this dilemma results from the rational business practices of focusing on the most promising markets and listening to one's customers. Focusing on the most promising markets and listening to its customers can blind a company to discontinuous innovations that, though they may not have a promising market in the near term and may not currently perform as well as the existing, highly perfected products, may nevertheless transform the market in a way that progressively displaces the incumbents. A key feature of this displacement process is that the emerging or transforming market is incompatible with the incumbent's business requirements (size of project, price, profit levels, facility characteristics, staff skills).

The list of well-performing, innovative companies that have failed as a result of a discontinuous innovation that changed their industry is lengthy and spans nearly every industrial sector.

Examples include:

- ◆ Sears Roebuck pioneered several important innovations in the retail arena in the 1960s (supply chain management, store brands, catalogue retaining, and credit card sales) but then completely ignored the advent of discount retailing, home centers, and financial innovations. Sears' credibility as a merchandising and financial innovator is now shaken and it is in danger of losing its standing as a competitive enterprise.
- ◆ IBM missed the advent of the mini computer, and later Digital Equipment Corporation missed the advent of the desktop computer.
- ◆ Similarly, Xerox was set back with the advent of tabletop photocopiers.
- ◆ Large integrated steel producers missed the advent of steel minimills.
- ◆ Leading mechanical cable-actuated manufacturers missed the transition to hydraulic excavation technology.
- ◆ Only twice in six times that new architectures overtook the disk drive industry did leaders in the field maintain their lead in the subsequent generation.

To combat this dilemma, innovative companies can try to focus on discontinuous as well as sustaining innovation. An established company can attempt to identify and develop discontinuous innovations, especially through spin-off organizations that are not bound by the contingencies that govern the larger firm. However, this strategy will not ensure that the company will be successful in identifying the next major innovation to affect that industrial sector. An established company can also actively scan potentially relevant developments in order to make sure it responds to and adapts to potentially threatening new technologies in a timely manner. It may be that an established firm, even if aware of potentially threatening changes in its environment, will not be able to change fast enough or dramatically enough. In these cases, the best strategy seems to be for the organization to create a separate organizational entity that has a business model appropriate for the emerging market and external environment.

To add to this innovation dilemma, there is growing evidence that many of the most innovative business reengineering projects have failed or fallen vastly short of expectations. In addition, it now appears that an increasing number of companies that were the exemplars of innovation are facing hard times (i.e., Lucent Technologies, Cisco, and most recently, Enron). Their decline is not due to the emergence of a new discontinuous innovation that threatened their competitive

edge. Rather, innovation is both expensive and risky, and the downturn in the economy has made stakeholders wary of the ability of these companies to continue to aggressively pursue these innovative business strategies.

It is obviously important that decisions regarding innovations take into account the desired benefits, the costs of undertaking the innovation, and the likelihood of success. The costs and likelihood of success have a great deal to do with how difficult it will be to implement the innovation and the impacts it will have on the organization as a whole. Some innovations do not require massive organizational changes while others can only succeed if the organization undergoes a fairly major transformation. Radical, especially discontinuous radical, innovations are likely to require major organizational change and can be most prone to failure but these are also likely to bring about the greatest benefits.

### What does it all Mean?

Innovation is important for companies across all sectors of the economy—manufacturing and services, high and low tech, in slowly and in rapidly changing environments. Keeping up with the latest innovations, as opposed to being an innovation leader, is a conservative strategy in that it allows the company to choose to adopt only those innovations that appear to be most successful. But this conservative strategy has drawbacks. Research shows that for companies across all sectors to be leaders requires that they be more innovative than the competition. However, the research also shows that companies must be wary of exceeding the benefits of innovation and/or incurring economic risks if they become overly innovative. Finally, the research suggests that being innovative does not necessarily guard against failure. Established companies in an industrial sector must be sufficiently diligent in scanning for and identifying potentially discontinuous innovations that may represent a threat to the dominant operational models. This scanning for and exploration of potentially discontinuous innovations can be done individually or collectively through industrial associations. In addition, the established companies must be prepared to know when and how best to make the necessary adjustments to potentially threatening innovations. The identification of potential threats is not sufficient. Being adept at responding and adapting to change is also a requisite to ensure that the company will be able to compete successfully in the future. As Hamel (2000) notes, an innovation competency may be *the* new competitive advantage in the new millennium. An innovation competency could help organizations better manage the risks as well as reap the benefits of innovation.

### ***The Application of Innovation to Public Science Management***

There may be several new ideas in this literature that could be of benefit to public science organizations. The innovation literature is in many ways becoming similar to the knowledge management literature in its focus on absorptive capacity and the fact that innovation is being approached increasingly from an organizational perspective and rather than exclusively from a project perspective. By understanding what contributes to innovation at the organizational level, public science directing and funding organizations can encourage these attributes in both public and private science executing organizations. In addition, greater understanding of how innovation is affected by the external environmental context could enable these public science directing and funding organizations to influence this context in ways that will promote scientific innovation. This literature indicates that public science directing and funding organizations could have a positive impact on innovation by promoting knowledge management processes that extend

beyond organizational boundaries, thereby helping science executing organizations access and incorporate the latest knowledge being developed across many sectors (for example science policy and direction, basic science findings, and technological advances). Cohen et al. (1990) and Fiol (1996) note that there is a need for both environmental (institutional) and organizational level analyses of how absorptive capacity can be enhanced. This literature also suggests that other environmental factors can influence the quality and quantity of innovation, such as adequate funding, stability, the level of competition, the extent of partnerships and collaborations (Kanter 1988; Amabile 1988; Jonash and Sommerlatte 1999). Public science directing and funding organizations need to take a hard look at how they may be hindering real innovation in science executing organizations, such as imposing too many bureaucratic requirements, being too slow in processing and funding proposals, etc. They can further collaborative with one another to foster a more effective environment for science executing organizations.

Public science executing organizations should make sure they employ state-of-the-art innovation processes. Many of the public science executing organizations are increasingly using spin-offs to bring scientific innovations to market. Many are beginning to play a lead role in enhancing key innovation processes, such as environmental scanning and data mining, forming partnerships, and designing and implementing knowledge management systems.

Although a great deal of the current innovation literature focuses on radical product innovation, the concept of innovation has become far broader in the last decade. Many of the newer perspectives on innovation overlap with the knowledge management and organizational partnerships and alliances literatures. These more recent perspectives on innovation have a greater relevance to public science management. In fact, most of the topics discussed in this book can be seen as process and/or strategy innovations, such as organizational partnerships, new perspectives on organizational strategy, developing and building competencies, and so on. The link between innovative outputs (such as products and services or new scientific discoveries in the case of science organizations) and innovative processes and organizational strategy is becoming increasingly clear. If science organizations are going to be successful, they will have to pay greater attention to organizational innovation as well as scientific innovation.

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