Managing Innovations, Standards and Organizational Capabilities

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Abstract- **Innovations and new product development provide the fuel for economic growth and the source for competitive advantage. Managing software innovation requires one set of organizational capabilities at the innovative, entrepreneurial phase and another set at later phases. Some early phase capabilities, such as flexibility, inherently conflict with some later phase capabilities, such as repeatability. The capability to manage both discontinuous, disruptive innovations and continuous, incremental innovations provides a sustainable competitive advantage. Technology managers who understand the phases of innovation, the critical role of standards and the various and sometimes conflicting capabilities needed to manage both new and mature product development, can better compete in today's rapidly changing environment. This paper describes a Capability Framework for managing both innovations and mature technology, grounded in both the literature and in the experience of successful and unsuccessful practices in start-up and mature software companies.**

I. Introduction

Economic growth depends on the successful commercialization and management of innovation and the retention and reinvestment of profits from those innovations. The ability to produce different kinds of innovations and manage them throughout the technology cycles provides a sustained competitive advantage. Mature firms have the resources to fund research and product introduction, but often fail to capitalize on innovations, sometimes because they are threatened by them. Entrepreneurial firms are able to get an innovation to market, but often fail to develop the capabilities needed to compete in a mature product environment. The dot com failures exemplify this.

The research for this paper includes an investigation of the practices of ten software companies between 1980 and 2001. I have chosen four of these companies for further consideration because their primary focus was delivering innovative software products, rather than system integration, application integration or consulting. Further research for this paper includes a review of the literature in order to extend the results to other industries. In this paper I provide a Capability Framework that describes how firms can compete in both the entrepreneurial and mature stages of an industry. In order to understand how to manage innovations successfully, we first need to understand the nature and dynamics of innovations. In the next section, we will explore the characteristic patterns of innovation. With this conceptual model, we will then define the capabilities needed for each phase of innovation. Finally I consider ways in which firms can incorporate both sets of capabilities. The Capability Framework as well as the models of technology cycles and patterns of innovation provide managers with a context and a set of tools for leading technology organizations.

II. Patterns and Phases of Innovations

We can characterize innovations in a number of ways. *Product* innovations include such things as calculators and computers. *Process* innovations include Dell's manufacturing and distribution processes and WalMart's supply chain process. *Conceptual* innovations include Copernicus' heliocentric model of the cosmos. *Disruptive* or *discontinuous* innovations include technologies that fundamentally change the way humans perform some activity; all of the examples given above are disruptive innovations. In contrast, *incremental* innovations improve the functionality, performance or usability of a given technology. The latest release of Oracle's database product includes incremental innovations; the most recent refinements to airport security procedures are incremental innovations.

A technology cycle typically follows a predictable pattern of behavior. It begins with a discontinuous innovation and proceeds through several phases of incremental innovations until the technology is mature. Once it is mature, it is subject to disruption by a discontinuous innovation. The cycle then begins again.

Foster [1] introduces the notion of an S-curve comparing *performance* and effort, a "graph of the relationship between the effort put into improving a product or process and the results one gets back for the investment." When a technology is reaching the limits of its potential, increasingly greater effort yields increasingly smaller improvements.

Rogers [2] describes a similar S-curve for innovations, based on cumulative *adopters*. Andersen [3] finds the same pattern in the graphs of cumulative *patents* awarded over time for a given technology. Each of these researchers found patterns that industry practitioners recognize: an innovation starts out slowly, takes off, and then levels off as it reaches maturity.

Fig. 1 depicts the S-curve in general terms as a graph of industry growth, measured by any one of the metrics (performance, patents or adopters) on the Y-axis and time on the X-axis. Three inflection points divide the S-curve into four distinct phases. The first inflection point represents the point in time at which entrepreneurs see the commercial value of the innovation. The second inflection point occurs when a standard emerges. The third inflection point occurs when users' needs are met or exceeded or when minimal performance improvements can expected.

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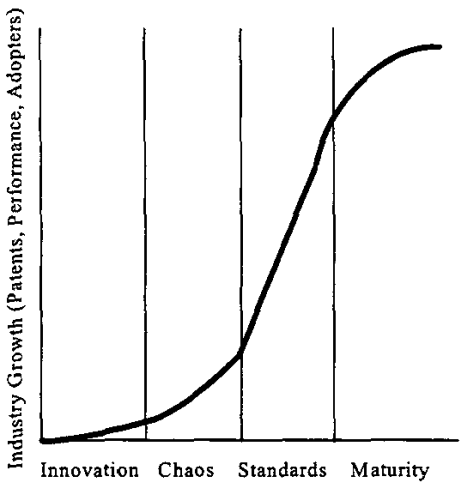

Fig. 1. Phases of innovation.

Managers face different challenges at different phases of innovation. In order to understand the challenges, we must first understand the dynamics. In this section, I present the regular patterns exhibited throughout history. Each cycle begins with a discontinuous innovation. If the innovation is successful, it proceeds through subsequent phases and includes later incremental innovations.

A. The Innovation Phase

The first phase is the creation of the innovation. Communities tend to see the innovation as a toy with little or no commercial value and to see the innovators as hobbyists or enthusiasts. Firms tend to see the innovation as inadequate to meet their customers' needs. Many innovations never reach the next stage.

When Samuel Morse presented the United States Congress with a prototype of his telegraph machine in 1838, his audience did not take him seriously. In the 1970s the mainframe computer industry viewed personal computers as toys for hobbyists who purchased kits to build them. Few firms saw the personal computer as having any real commercial value. When their scientists invented the adhesive for Post-it® Notes in the 1970s, 3M managers were skeptical about an adhesive that made only intermittent contact.

The Innovation Phase is characterized by experimentation and little notice by or interest from either firms or consumers.

B. Chaos and Commercialization Phase

The first inflection point on the S-curve occurs when entrepreneurs see the commercial value of the innovation and try to build a business around the innovation.

As entrepreneurs saw the commercial value of the telegraph, dozens of companies began building telegraph networks, stringing lines haphazardly across the United States. To avoid patent infringements, companies developed unique telegraph systems, incompatible with each other. Creating the telegraph infrastructure was expensive, and dozens of companies failed before becoming profitable. In contrast, the telegraph systems grew in Europe and England because they had government sponsorship. But each country's system was incompatible with that of its neighbors. Standards did not yet exist.

As entrepreneurs saw the value of PCs, many companies emerged to give us the KayPro, the Commodore, the Apple Lisa, the DEC Rainbow and the Victor 9000, none of which was compatible with the others. Software written for one did not work on any others. Nor did they communicate with one another. This is not surprising. Just as we have no laws to govern something we have never imagined before, we have no standards to guide discontinuous innovations.

The characteristics of the Chaos and Commercialization Phase are hype, disappointments, fear, suspicion, many entrants, incompatible systems and no standards.

An indicator that this phase is coming to a close and the next phase is about to begin is that governments see the innovation as important to national interests. Both governments and consumers call for standards and interoperability

C. Standards Phase

The Standards Phase has three characteristics: the emergence of a standard or dominant design, rapid growth, and industry consolidation. The industry as a whole reaches a critical mass, grows rapidly, and all participants aligned with the standard benefit. During this phase, incremental innovations are important.

The two most important factors in the growth of any industry are the innovation itself and the emergence or selection of a standard. Why are innovations and industry standards so important? Without the innovation, the industry would not exist. Without the standard, the industry would not flourish.

Standards bodies such as IEEE sometimes determine an industry standard. At other times market and industry forces determine the *de facto* standard. Anderson and Tushman [4] found that industry standards typically lag the leading edge of technology. While a sub-optimal standard limits economic gains, it is better than no standard at all.

The 1865 international conference on the telegraph yielded the International Telegraph Union, still in existence today. This early standards body worked to unify the many disparate systems and marked a turning point in the telegraph industry. Its work helped to expand the telegraph throughout the world at a remarkable speed.

IBM introduced the IBM PC in 1982. With its strong brand and high level of trust from the business world, it created a *de facto* standard overnight. This marked the turning point for the personal computer industry. Those participating in the standard flourished. Compaq and Dell began building PCs; Microsoft, Lotus, Borland, Oracle and WordPerfect began building software; Intel's processor business grew rapidly. Service providers began offering custom software to run businesses.

Once a standard emerges, industry consolidation follows quickly. Almost all the companies building personal computers (other than IBM PC-compatibles) failed in 1983. In general, at this phase, companies whose products are not aligned with the *de facto* standard fail; companies whose products are aligned with the standard grow. Companies compete during this phase by adding functionality through continuous, incremental improvements to their products and by improving processes in order to increase efficiency.

D. Maturity Phase

The final inflection point on the S-curve comes when products meet or exceed customers' needs for functionality, or when the technology has reached its natural limits. Competition shifts to customer service and to production and distribution efficiencies. Process innovation is most important at this phase.

The personal computer industry is in this phase now. Dell, whose strength is in just-in-time production, rather than in enhancing functionality through innovation, has a competitive edge for this phase. At the Maturity Phase, discontinuous innovations which provide further performance capability or which are simpler and cheaper can disrupt the industry and start the next technology cycle.

III. Capability Framework

Different phases of innovation require different management, engineering, marketing, and operations capabilities. For our purposes, we will consider the Early Phase to include both the discontinuous innovation itself and the Chaos and Commercialization Phase. The Later Phase will include the Standards Phase and the Maturity Phase.

A. Early Phase Capabilities

What are some of the cultural norms and behaviors that foster the successful commercialization of a discontinuous innovation? A culture that encourages strong ties with customers, risk taking, experimentation and openness is more likely to foster successful innovation.

My study of software product companies included two firms that introduced innovative products and gained a large majority of market share. The first firm produced a mainframe financial planning tool in the late 1970s and was among the top 20 software product companies in the world in annual revenues by 1980.

What were the capabilities that contributed to the financial planning software company's success? It provided a complete solution for customers, including the installation, configuration, customization, consulting and support of its product. Employees had strong ties with customers, and the relationships were characterized by trust and involvement. The scientist who created the product understood the business needs, the customer needs and the delivery dates. He was ultimately able to handle all the tasks that others failed to complete on time.

The second firm produced networking operating system software, and held 70% market share of a growing market. The capabilities that contributed to its success are very similar to those of the financial planning software company. During the early phase, 1986–1989, this firm provided an end-to-end solution, including hardware, installation, configuration, customization, consulting and support. Its culture fostered a collaborative relationship with customers and other industry participants. And the engineer who designed the product understood the business needs, the customer needs, and was able to direct closely the efforts of other engineers to bring the product to completion.

During the early phase of an innovation there are a significant number of unknown issues that are only uncovered during development. Not surprisingly, both of these first two firms had difficulty in designing and scoping their initial products; effective scoping is an inherent problem in the early phase. In both cases flexibility and the commitment of the principal engineer overcame these obstacles and contributed to success.

A third firm produced web-based configuration software. It was able to gain some early success, but failed quickly. It lacked the close relationship with customers and failed to build relationships with partners. Although product designers were able to complete the products, they did not understand either business needs or customer needs.

A fourth firm produced web content management software. It had a far more mature approach to software development than the configuration software provider, but also lacked a close relationship with customers. It had some early success but is now struggling.

Each of the firms in this study was aggressive and willing to take significant risks. Although none of the firms was the original innovator, each of the entrepreneurs leading the firms saw the value of the innovation and built a business around it.

All four of the firms focused their attention on taking the initial innovation and adding features. The financial planning software firm created an initial product with basic functionality such as summing rows and columns, and added customer-requested features such as optimization and Monte Carlo simulation.

The network operating system firm created an initial product with file and print services, and added customer-requested functionality, such as directory services and network management.

The web-based configuration software firm created additional features but in contrast with the first two firms, these features typically originated in the creative minds of the developers rather than from customers.

The content management software firm created additional features based more on the ideas of the marketing team than on close, long-term relationships with customers.

Managing involves using various control systems. Control systems include both formal control systems and social norms. What is an effective way to manage or control an innovative organization where

work is non-repetitive and not routine? Change is frequent. Formal control systems are inappropriate here. Formal control systems involve instructing employees in what to do and how to do it, and monitoring their behavior. Instead, managers in departments responsible for innovation need to be clear about the firm's vision and objectives and rely on employees' judgment. This held true for both of the successful software firms.

In departments with predictable, regular and repeated activities such as internal information technology, manufacturing, inventory management, cash flow management and human resources, managers can rely on formal control systems. This organizational behavior is in tension with that in the research and development departments. We'll address this tension in the section on Ambidextrous Organizations.

Kanter, North, Richardson, Ingols and Zoler [5] suggest "routinizing the unpredictable" in their study of Raytheon's New Product Center, where the goal was to aid the company's growth and profits by developing new products. They found that characteristics such as having modest goals, a patient sponsor, good coordination with the rest of the company, client involvement, product champions and prototypes led to the Center's success. They found that the relationship with clients, including trust and good channels of communication so that the innovators could understand the client business, was the "make-or-break" issue.

3M is well known for its approach to innovation. Employees are encouraged to spend 15 percent of their time engaged in exploration and innovation. The 3M lab system includes three levels of labs, more closely or loosely aligned with a given business unit. And 3M's stated goal is to have 30 percent of revenues come from products introduced in the last four years. A discontinuous innovation is typically designed for functionality, rather than designed for manufacturing. Companies such as 3M understand the need to move quickly to design for manufacturing.

Let's summarize the capabilities needed during the early phase. When an innovative product is first introduced, firms need skills and capabilities to cope with fear and chaos in the marketplace. Companies need to provide an end-to-end solution. This serves two purposes. First, it mitigates the fear that accompanies the innovative phase. And second, during the early phase of an innovation, there are typically no available partners. When an invention first comes to market, there is no industry to install or service that product. Innovative products are usually proprietary, lacking compatibility or interoperability.

A second capability that differentiated the successful firms from the less successful ones is the relationship of trust and collaboration with initial customers. The relationships mitigate customer fears and provide the innovators with better knowledge of what is valuable to the customers.

All four of the software firms in this study understood that the initial product development teams would have difficulty in designing and scoping their products. All exhibited flexibility and planned for buffers to accommodate this difficulty. All had bright dedicated engineers who could drive development to completion.

B. Late Phase Capability

What are the capabilities that firms need to manage during the Standards and Maturity Phases of a innovation cycle? Once a standard emerges, competition shifts to incremental innovations and process improvement. The firm's focus moves to operational efficiency. Process innovations can help a firm compete with more operational efficiency. Additionally interoperability and alliances play a significant role.

The financial planning software firm developed processes for source control, managing the software build process, regression testing, planning, designing and scoping. These were repeatable, optimized processes. The relationship with customers continued to be important, but, in contrast with practices valuable in the early phase, in the later phase some mediation and distance are valuable for their contribution to efficiency. The primary engineers were sheltered by intermediaries, typically product managers, implementation engineers, and customer support engineers. These capabilities all contributed to its continued success.

The network operating system firm developed similar processes and disseminated them throughout a geographically dispersed development group. The firm relied heavily on configuration management, source control, automated testing and an impressive test lab which enabled extensive testing in heterogeneous environments. It standardized the software build and installation processes. It relied on distributors and resellers for product sales and distribution.

In the late 1980s and early 1990s, a significant problem for customers was technical support. If a personal computer's software did not perform as a customer expected, the customer was unlikely to know which product was at the heart of the problem. To address this source of customer frustration, the firm pioneered the idea of a support alliance, which allowed the customer to get appropriate help no matter which vendor he or she called.

These activities served to automate and make many processes routine, predictable and repeatable, and to improve the reliability of the product.

The web content management software firm made some attempts to build alliances and partnerships. However, it is caught in a very typical tangle: it relies heavily on the revenues from its consulting business and has been unable to build significant alliances. It has been successful at improving repeatable processes.

Finally, during the last part of the late phase, firms need to attack and cannibalize themselves, participating in what Schumpeter [6] calls Creative Destruction. They need to understand limits and when it is time for the next discontinuous innovation.

Firms in mature industries must shift and replace the quest for efficiency with the quest for competitiveness. While efficiency is the capability that works during the Maturity Phase, at some point it will be undermined by a new technology. This is the point at which firms that want to remain competitive must cannibalize their own markets, and participate in Creative Destruction. Table 1 summarizes the Capability Framework.

C. *The Capability Bridge*

How do firms make the leap from innovative and entrepreneurial to mature? The first two firms in the study successfully made this transition. They both had good leaders who articulated the vision and goals.

Both the financial planning software firm and the network operating system firm built internal infrastructures which included systems for repeatable, efficient execution, including quality groups, process improvement groups, planning and sophisticated documentation organizations. The network operating system firm set the standard for its industry, and led the growth of that industry through fostering alliances and partnerships. Management focused on growing the industry rather than on maintaining a proprietary solution.

Finally, the latter firm divested itself of non-core business and created a strategy based on its competitive advantage and on maintaining control of the platform. Prior to 1989, 50% of revenues came from hardware sales (approximately $250 million). In 1989, the firm seeded the market for partners by giving away the hardware designs, and its revenues continued to increase. It also encouraged the growth of the industry by providing training and certification to potential partners in installation, administration, customization, application building and consulting. Instead of providing an end-to-end solution, the firm relied on partners to provide all the tangential aspects of the business.

This was not simply a generous move, it was a defensive tactic. Other industry participants, whose business was built on this firm's platform, had an interest in its continued success. The firm's conscious strategy to grow the industry (rather than maintain control over a proprietary system) created the standard and propelled the industry into the Standards Phase.

IV. AMBIDEXTROUS ORGANIZATIONS

In the early- to mid-1980s the personal computer industry disrupted the mainframe industry. The financial planning software firm's executives recognized this threat and funded an effort to create software for the PC. However, the firm failed to build the organizational capabilities to market and sell into a new price-sensitive marketplace.

Tushman and Anderson [7] use the term "ambidextrous organization" to describe the approach managers must take to handle both the entrepreneurial and mature aspects of a firm. What this firm needed was an ambidextrous organization, able to manage the existing technology and at the same time, bring new technology to market.

TABLE I
CAPABILITY FRAMEWORK

	Early Phase	Late Phase
Innovation Focus	Discontinuous, followed by incremental	Incremental and process
Product Focus	Features, performance	Performance, reliability and cost
Product Development	Inventor / Engineer drives development to completion	Routine process drives development to completion
Customer Relationships	Close, collaborative	Some distance, mediated
Industry Relationships	Provide and end-to-end solution	Enable partners to provide parts of solution
Processes	Flexible, adaptable	Efficient, process-oriented
Posture	Aggressive, risk-taking	Defensive, but ultimately attack self in Creative Destruction

The sales organization's structures and processes were constructed for sales of approximately $100,000 and could not adapt to sales of products costing under $1000. There was no distribution or support system in place for high-volume, low-priced products. Ultimately the financial planning software firm, with very talented employees and a very sophisticated and useful product, failed. It was disrupted by an innovation which required a move to a lower value network. The firm's leaders were very intelligent people. If their tool box had included the conceptual models of technology cycles, the patterns of innovation and the necessity for Creative Destruction, they might have been able to drive that renewal process internally. This would have required creating separate organizations, each with cost structures and systems appropriate to its value network. Christensen [8] describes the problem of moving from a higher value network to a lower one and the risk of disruptive innovations.

It is difficult for companies to have both kinds of capabilities because the capabilities are in tension with each other.

Managers understand that their firm needs innovations in order to grow and they are often supportive of innovative efforts. But all firms deal with the reality of limited resources, and during the debates on resource allocation, established managers will attempt to control resources even if that means denying them to the entrepreneurial units of the business.

In addition to the inherent tension between capabilities such as flexibility and efficiency, established managers often undermine innovation; it is difficult to support the efforts that will lead to your own demise. It is easy for each group to disparage the practices of the other. One has no process; the other is too rigid. One focuses on features despite the cost; the other focuses on reliability and cost containment.

One is too close to customers; the other is too distant from customers. One is aggressive; the other is defensive.

Ambidextrous organizations require leaders who can articulate the vision and maintain a balance between organizations with very different structures, processes and practices. And they require managers who can tolerate the risk to their careers that innovation poses.

Ambidextrous organizations have the capabilities to support simultaneous discontinuous and incremental innovations. They are inherently unstable. They require leaders who can see the longer term value that the ability to produce different kinds of innovation provides.

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