STRATEGY

STRATEGIES FOR SUCCESSFUL TECHNOLOGICAL DEVELOPMENT

C. Christopher Baughn and Richard N. Osborne

The challenges stemming from globalization coupled with more rapid, fundamental technological development compels firms to develop more effective ways to manage. The corporate landscape will change as some firms successfully traverse turbulent periods of industry evolution while others do not. Firms may increase their chances of success by developing a portfolio of alliances in technology development, emphasizing organizational learning, and altering traditional views of strategy and control.

In recent years both business scholars and top management have become increasingly concerned with the effective management of technology. (1,2) The growing appreciation of technology's importance as a critical competitive dimension can be linked to the escalating speed and scope of technological innovation, as well as to the dramatic increase in the number and global dispersion of technologically advanced competitors.

The late 1970s and early 80s have witnessed almost simultaneous commercialization of many technologies across Japan, Western Europe, and North America. Intense international competition now involves the race to dominate new technological frontiers. In addition, new combinations of materials and processes will spawn new industries. Firms unable to adapt to changing technological conditions will often be displaced, as we have seen in the transition from vacuum tube manufacture to transistors, and then to chips.

Faced with such increasingly critical and turbulent technological conditions, firms are beginning to consider the development of technology strategies. (3,4) The purpose of this paper is to present a strategic perspective that emerges from examination of the technology development process and its more general context. Using this perspective, several elements of an adaptive technology strategy and supporting processes are derived.

SHAPING AND RESPONDING TO LIFE CYCLES

Many approaches to technological innovation and strategy have dealt with assessment of the impact of industry/product life cycles and their underlying technology life cycles. The technological life cycle is often depicted as an S-shaped curve. After an initial breakthrough, the rate of innovation builds gradually. This is followed by a marked acceleration in the introduction of new applications and improvements. Over time however, the rate stabilizes and eventually declines as the technology is displaced. This life cycle also reflects an increasing interdependence between product and process technologies. There is a natural transition from a "fluid" state of technology to a more "specific" state. (5) Early in the life cycled of a given technology, product innovation receives more attention than specific process innovations. Over time, the relationship between product and process shapes and constrains the innovation process.

As changes in product design begin to slow down and the product becomes increasingly standardized, mass-production techniques can be introduced. Costs of capital equipment, specialized labor, and components limit the potential for subsequent design modifications. At this point, process innovations to cut costs become the primary form of technical activity. Eventually the number of process innovations tapers off as well. (7)

In Figure 1 we see the associated industry life cycle depicting changes in industry activity (such as revenues) over time. Changes in product and process emphasis in each stage of the life cycle are also charted. The embryonic stage is characterized
by uncertainty in technology, markets, and competition. Following a period of rapid growth and exploitation, both economic and technological outcomes become more predictable and the number of competitors stabilizes. (8) With the introduction of standardized manufacture, firms can capitalize on economies of scale. In the "growth" and "mature" stages of the industry life cycle, firms may recover the costs of research and development and perhaps realize substantial profits. Revenues in the mature stage are relatively high, though the industry may be vulnerable to innovations (frequently from firms outside the industry, which are not wedded to the same "core concepts" or capital equipment) and subsequent displacement. (9,10)

Indeed, the development of new technologies is causing rapid product obsolescence, shortening product life cycles, and displacing manufacturing processes. (11,12) In many high-technology markets entire generations of technology come and go within a few years. Between 1982 and 1985, for example, three generations of floppy and Winchester disk drives were introduced in the computer industry. (13) And now the optical disk is just on the horizon.

**Strategic Responses to an Accelerating Life Cycle**

The life-cycle concept has been used to generate specific adaptive strategies. Many center on the timing of a firm's actions to anticipate changes in the life cycle. For instance, managers are advised to project the limits in possible improvement of their technology and provide the greatest R&D resource allocation to programs showing the greatest technological (as well as market) potential. (14) As technological limits are approached (evidenced by such symptoms as declining R&D productivity and increasing process vs. product improvement) managers are advised to search for technological discontinuities. (15) Further, firms must build into their plans the timing of possible licensing or sale of the technology. Traditionally firms would not want to market a technology until late in the cycle because such actions merely help to create competitors. With the increasing speed of development however, firms may need to accelerate their licensing programs because they risk losing the ability to exploit their technological assets (and possible use of income gained to pay for development of subsequent innovations) by holding on to degraded technology. (16)

During the maturity stage there appears to be general agreement that cost factors and a whole host of non-manufacturing considerations may provide firms with a competitive advantage. Favorable currency exchange rates, less restrictive governmental regulations, favorable trade policies, and even direct governmental subsidies may play an important role in providing cost advantages. Such cost advantages become critical when product differentiation based on technological considerations is not salient. Mendell and Ennis note for example, that much of the blame for the US decline in innovation and competitiveness has been attributed to the natural consequences of the maturation of industries in which the US once dominated. (17) As US industries reached a mature stage of development, the rate of technologi-