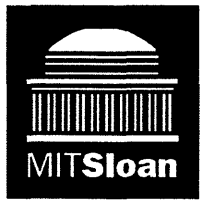

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Dynamic Competitive Strategies: A Technological Evolution Perspective

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Abstract

We propose a dynamic model based on a technological evolution perspective which suggests a link between the product-market position and the resource-based views of competitive advantage. Drawing on the Utterback and Abernathy (1975) model of innovation, the Utterback (1994) model on the dynamics of innovation among multiple productive units, and other models of technological and industry evolution, we argue that the technologies which underlie low cost, product differentiation, and firm heterogeneous capabilities evolve over time as the firms exploiting them interact with their environments. As technology evolves, so do industry characteristics and critical success factors. Technological evolution influences the kinds of products (niche, differentiated or low cost) offered over time. Firms that do not have the capabilities to offer appropriate products, may be forced to exit. Thus an industry's attractiveness and the kinds of capabilities that a firm needs to succeed, may also vary over time suggesting different strategies for each phase. A firm's strategies and heterogeneous capability at one stage may depend on its strategy, and capabilities in previous stages of development.

1. INTRODUCTION

Two streams of research have been useful in explaining the sources of competitive advantage. The first, the product-market position view, holds that a firm's profitability depends on the attractiveness of the industry in which the firm competes and its positioning in the industry as well as its proximate environment (Porter, 1980, 1985, 1990, 1991). The second, the resource-based perspective, maintains that a firm makes profits from having competences and firm-specific assets[1] that are scarce, imperfectly imitable, imperfectly tradable, and difficult to replicate (Rumelt, 1984; Teece, 1984; Wernerfelt, 1984; Cool and Schendel, 1988; Prahalad and Hamel, 1990; Quinn, 1992; Burgelman, 1993; Henderson, 1994). Both perspectives are static. They explain what it takes to be profitable at any point and time. But industry structures are not static. Barriers to entry, the nature and sources of substitutes, the number and kinds of rivals, suppliers and customers often change making what is an attractive industry and product-market position today not so attractive tomorrow. Competences that once were useful in exploiting certain markets may be rendered obsolete by structural changes such as deregulation or technological discontinuities (Tushman and Anderson, 1986; Henderson and Clark, 1990; Cooper and Schendel, 1976). Irreversible investments in things like plants can also be rendered obsolete.

We argue that the search for a dynamic theory of strategy and for a link between the product-market and resource-based views may be incomplete without an exploration of the evolution of the technology that underlies products and heterogeneous firm capability. Our argument rests on the Utterback and Abernathy (1975) dynamic model of innovation, the Utterback & Kim (1986) hypotheses on discontinuous change in a product, and the Utterback and Suarez (1993) model on the dynamics of innovation among multiple productive units. The models suggest that technology evolves as the firms exploiting it interact with their environments. As the technology evolves, so do industry structure, attractiveness and critical success factors. The evolution determines what kinds of products (low cost, niche or differentiated) can be offered at each of the stages of evolution. To offer any of these products (and therefore survive), a firm needs certain kinds of strategies and capabilities. The firms that don't have these capabilities and therefore cannot offer the specific products of the particular stage, are forced to exit. Thus an industry's attractiveness and the kinds of capabilities that a firm needs to succeed also vary from one stage of the evolution to the other, suggesting different strategies for each stage. A firm's heterogeneous capability in the latter part of the evolution, and therefore its strategy, can be

[1] There is some confusion in the strategy literature when it comes to the definition of capabilities, resources, firm-specific assets, and competences. In this, paper, we the words resources and firm-specific assets are used interchangeably. Competences + resources (or firm-specific assets) = capabilities. These relationships are in line with Goodman and Lawless (1993).

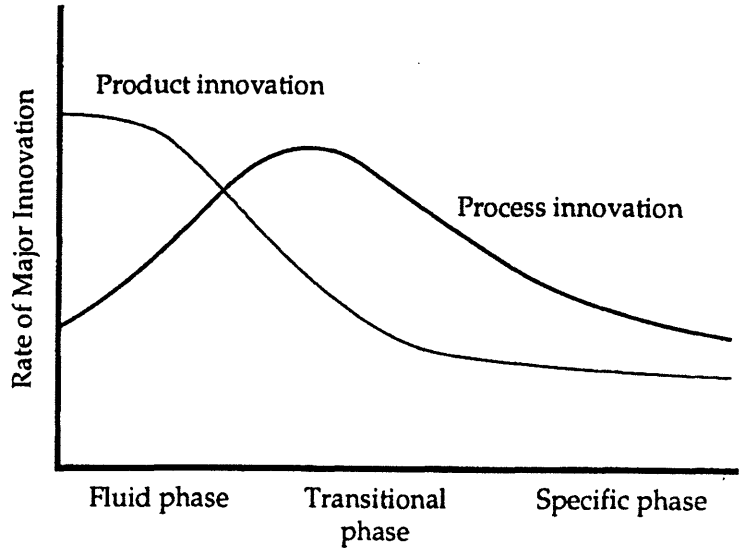
expected to depend on its strategies, capabilities and market positioning early in the life of the technology.

The paper is organized as follows: In the next section, we review the Utterback and Abernathy (1975) dynamic model of innovation and the Utterback and Suarez (1993) model on the dynamics of innovation among multiple productive units, as well as the product market-position and resource-based static models to lay the groundwork for the dynamic competitive model that follows. In Section 3, we present the model. At each phase of the technological evolution cycle, we explore the pressures exerted by Porter's (1980) five forces and suggest strategies that anticipate the needs of that phase and the phase(s) that follow. We also explore the competences that are required to offer the products of each phase and the extent to which each firm's unique capabilities allow it to offer those products. In Section 4, we summarize our arguments and discuss some issues for further research.

2. BACKGROUND MATERIAL

Technological Evolution and the Firm

The Utterback and Abernathy dynamic model of innovation (Utterback and Abernathy, 1975; Abernathy, 1978; Abernathy and Utterback, 1978; and Utterback, 1994) details the dynamic processes that take place within an industry and within member firms during the evolution of a technology. Figure 1 summarizes the key elements of the model. In the fluid phase, there is a lot of product and market uncertainty. Technology is in a state of flux and firms have no clear idea where to place their R&D bets. This is exacerbated by the fact that it is not quite clear what the target market is or what product features will best serve the market's interests. Custom designs are common with the new product technology often being crude, expensive and unreliable but able to fill a function in a way that is desirable in some niche market. These designs are in some ways but experiments in the market place, and the rate of product change is expected to be high as producers learn more about market needs, and customers understand more about the possibilities of the evolving technology. Process innovation accounts for very little in the fluid phase and input materials are largely off-the-shelf, and manufacturing equipment mostly general purpose and the labor used largely very skilled. This allows for process flexibility since process changes are frequent in the fluid phase. The basis of competition is on product features. Brand names may not account for much at this point since producers are still unknown quantities.



Product	From high variety, to dominant design, to incremental innovation on standardized products
Process	Manufacturing progresses from heavy reliance on skilled labor and general-purpose equipment to specialized equipment tended by low-skilled labor
Organization	From entrepreneurial *organic* firm to hierarchical *mechanistic* firm with defined tasks and procedures and few rewards for radical innovation
Market	From fragmented and unstable with diverse products and rapid feedback to commodity-like with largely undifferentiated products
Competition	From many small firms with unique products to an oligopoly of firms with similar products

Figure 1: Key elements of the dynamic process of innovation (Utterback, 1994)

The evolution enters the transitional phase when, as producers learn more about how to meet customer needs through producer-customer interaction and through product experimentation, some standardization of components, market needs and product design features takes place, and a dominant design emerges signaling a substantial reduction in uncertainty, experimentation and major design changes. A dominant design is one whose major components and underlying core concepts don't vary substantially from one product model to the other, and the design commands a high percentage of the market share (Utterback and Abernathy, 1975; Henderson and Clark, 1990; Suarez and Utterback, 1995; Utterback, 1994). Competitive emphasis shifts to meeting the needs of specific customers which have now become more clearly understood. The rate of product innovations decreases and emphasis shifts to process innovation. Materials become more specialized and equipment more specialized and expensive. Competition is based on differentiated products.

In the specific phase, products built around the dominant design proliferate, and there is more and more emphasis on process innovation with product innovations being largely incremental. Materials and equipment become highly specialized. The basis for competition becomes low cost. Products are highly defined with differences between competitors' products often fewer than similarities. Even very complex products like automobiles tend to follow very similar designs and manufacturing protocols having essentially the same aerodynamic shape, similar engines, interiors and so forth. The link between product design and process is now close and very small design changes may be viewed as revolutionary by manufacturing.

Technological Discontinuity—The invading technology

According to Utterback and Kim (1986) and Utterback (1994), the pattern described above repeats itself when a new technology with the potential to render the old one non-competitive (see Figure 2) is introduced, often by a competitor from outside the established industry. This results in a discontinuity, plunging the innovation cycle back to the fluid phase with another wave of entering firms. Some of the entrants in each wave may be larger firms having a different set of competences than the established competitors. As Figure 3 shows, firms exploiting the old technology usually fight back with more incremental innovations.

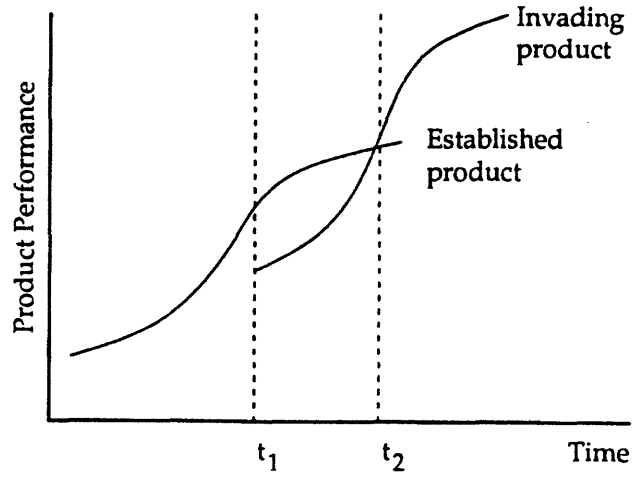


Figure 2: The Invaded and invading technologies (Utterback, 1994)

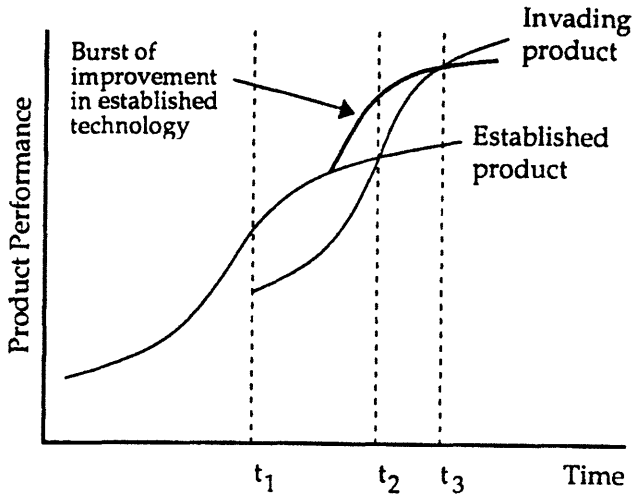


Figure 3: The invaded technology usually fights and makes large improvements (Utterback, 1994)

Technological Evolution and Industry structure

The dynamic process described above also has a direct effect on industry structure. Utterback and Abernathy (1975) and Utterback (1994) suggest that competition in an industry is a reflection of the changes in products and processes stemming from technological evolution. This is depicted in Figure 4. Thus, in the fluid state where product and market requirements are still ambiguous, there is expected to be rapid entry of firms with very few or no failures. The appearance of a dominant design shifts the competitive emphasis to favor those firms with greater skill in process innovation and process integration, and with more highly developed internal technical and engineering skills focused on the dominant design. Many firms will be unable to compete effectively and will fail. Others may possess special capabilities and thus merge successfully with dominant firms, whereas weaker firms may merge and still fail. Eventually, the market reaches a point of stability, corresponding to the specific state, in which there are only a few firms—four or five is a typical number—having standardized or slightly differentiated products, and relatively stable sales and market shares. Figure 4 portrays the relationship between the industrial innovation cycle and market structure.

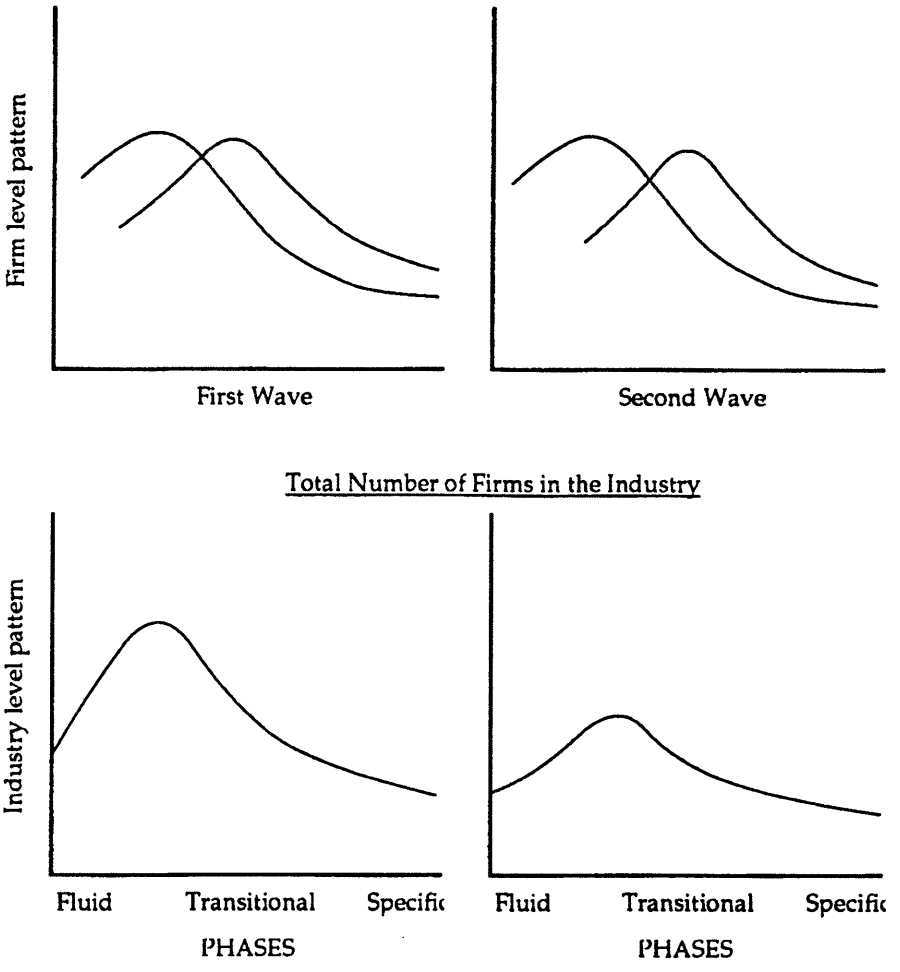


Figure 4: Waves of innovation and industry structure (Utterback, 1994)

Mueller and Tilton (1969) present similar arguments. Empirical evidence also supports this pattern[2] (Gort and Klepper, 1982; Klepper and Graddy 1990; Klepper and Simons, 1993; Utterback and Suarez, 1993; Utterback, 1994). Tushman and Rosenkopf (1992) also describe a technology life cycle with four components: technological discontinuities, eras of ferment, dominant designs, and eras of incremental change which correspond, respectively, to the discontinuity, fluid, transitional and specific phases of the Abernathy and Utterback (1978) model[3].

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[2] In some cases, however, the emergence of a dominant design may also increase the number of entrants. For example, the establishment of the PC standard with IBM's entry into the PC market in 1981, was actually followed by an increase in the number of new entrants.

[3] The main difference between the two models is the larger emphasis on the role of society in reinforcing the trajectory of firms in the industry by the Tushman and Rosenkopf model. The effect of society and complexity of the

Figure 5 shows how the structure of an industry changes over the life of the underlying technology. It illustrates the case of the supercomputer industry where until the 1980s, Cray Research and Control Data Corporation (CDC) dominated the market. In the early 1980s, new entrants entered using minisupercomputers technology. In the mid-1980s, others entered with massively parallel processor technology. In the 1990s more firms are failing, signaling some semblance of the emergence of a dominant design.

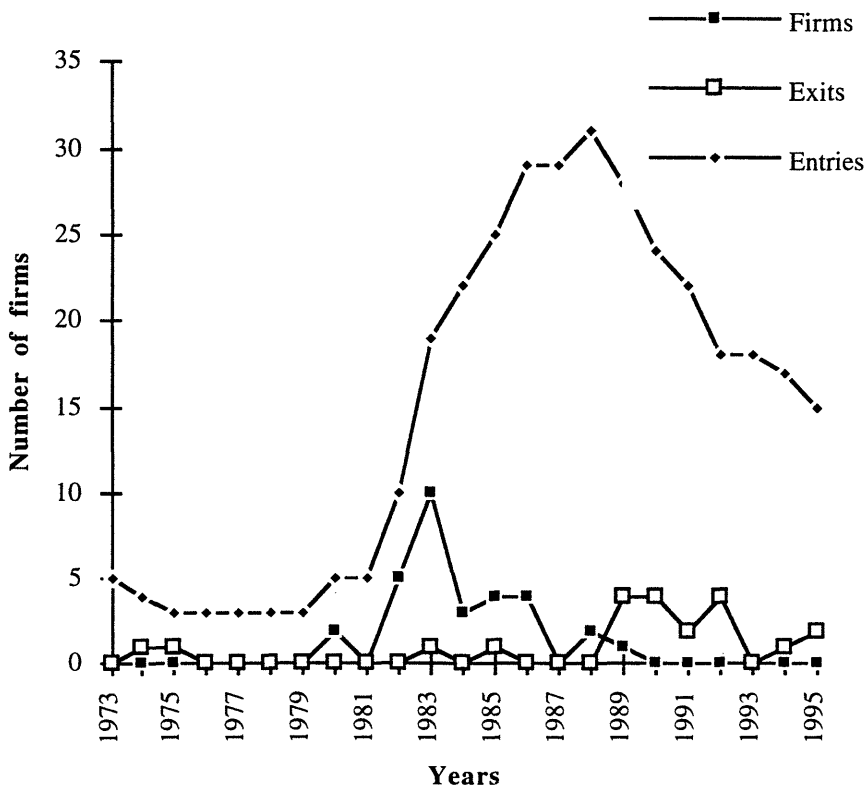

Figure 5: Number of firms participating in the supercomputer industry

Current Models for Strategic Analysis

Product Market Position

The evolution of industry structure and the changes in critical success factors suggest that each phase of the industrial innovation cycle requires a different strategy and that success at any phase is a function of present and previous strategies. However, dominant industry strategy models have been static. We briefly describe each of these as part of the background information for the model that we present shortly. According to Porter (1980, 1990, 1991) the success of a

product is to delay the rate at which technology moves from one phase to the other. Extensive work has also been done in this area by Nelson (1994), Nelson and Winter (1977, 1982) and Rosenberg (1982).

firm and therefore its choice of competitive strategy are deeply rooted in the structure of the industry in which it operates, its position in the industry and its proximate environment. Competition varies from industry to industry, and so do the opportunities for sustained profitability. It also varies from nation to nation, and sometimes from region to region as a function of the proximate environment (Porter, 1990). For each industry, five competitive forces combine to erode the long term profitability of any industry or segment of it: the threat of new entrants, the threat of substitute products or services, the bargaining power of suppliers, the bargaining power of buyers and the rivalry among existing competitors. The stronger these forces in an industry, the lower the profitability of the industry. New entrants increase competition and therefore drive down profit margins. Availability of close substitutes makes it more difficult for the manufacturer to raise its prices without driving customers to waiting substitutes. Powerful suppliers can increase cost while powerful customers can bargain away profit margins. Rivalry among competitors results in erosion of profit margins in the form of lower prices for customers and increased cost of sales. The strength of each of the five forces is a function of industry structure. For example, the threat of entry is a function of entry barriers such as the history of retaliation of incumbents, brand loyalty, or economies of scale. Some industries, by their nature, offer more attractive opportunities for sustainable profits than others.

A firm's positioning relative to its rivals within an industry determines its profitability relative to these rivals. The firm can position itself as a producer of low cost or differentiated products

Resource-based view

In the "resource-based" view (Rumelt, 1984; Teece, 1984; Wernerfelt, 1984; Cool and Schendel, 1988; Prahalad and Hamel, 1990; Quinn, 1992; Burgelman, 1993; Henderson, 1994), the focus is on the firm, in particular, on its unique capabilities. Success comes not from being well-positioned in an attractive industry but from having firm-specific assets and competences that are difficult to imitate, replicate or substitute. Firm-specific assets includes such things as reputation, patents, trademarks, specialized production facilities and computer installed base. A firm's competence is its ability to integrate different skills and knowledge among individuals, groups and organizations to deliver high perceived customer value (Prahalad and Hamel, 1990; Hamel and Prahalad, 1994). Firms usually do not have the organizational capacity to quickly develop new resources.

Not all the competences and resources are focused on product development. Some are customer-focused. For example, a firm's ability to synthesize customer needs into product attributes and into a language that product developers can implement technologically is invaluable. A firm may also have developed customer-focused resources such as brand name recognition,

reputation for high quality products, networks of service centers, distribution channels, and user networks. Some of these competences may also be focused on suppliers. For example, close and trusting supplier relations that allow for co-development of components or close monitoring of incremental innovations from suppliers. In other industries where complementary products are important, the ability to deal with complementary innovators may be critical. For example, since software is critical to the success of every computer, a computer maker's reputation and relationship with independent software vendors can be a critical factor in succeeding.

3. DYNAMIC COMPETITIVENESS ANALYSIS MODEL

From the models just reviewed, it is evident that industry structure, the types of products that can be offered, as well as the nature of competences and resources that a firm needs to be profitable, vary from one phase of the industrial innovation cycle to the other. The attractiveness of an industry to a firm is therefore a function, not only of the forces being exerted in the present phase, but of the competences of the firm and the actions it took in the previous phase(s). We suggest, and outline below, a three-step dynamic competitive analysis process. First, at each of the four phases of the industrial innovation cycle, the firm analyzes the pressures being exerted by Porter's (1980) five forces to determine the industry's attractiveness. This is illustrated in Figure 6. We suggest looking at a sixth force—the threat of invading technologies. Second, the firm evaluates the extent to which its competences and resources meet the levels and quality needed to be successful at each phase. Finally, at each phase, the firm takes strategic steps that also anticipate the nature of the next phase(s). We explore industry attractiveness first, and then the capabilities required to provide the necessary products.

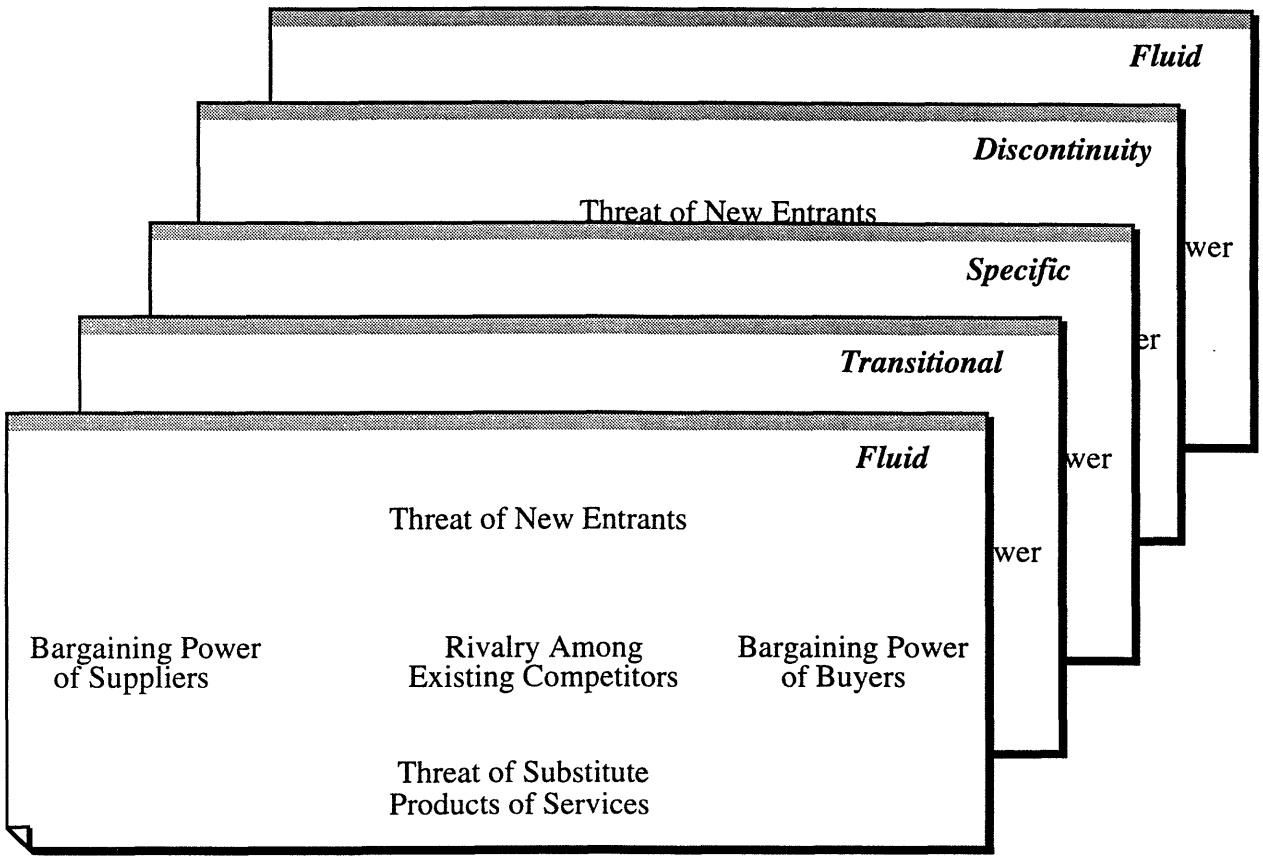

Figure 6: Industry attractiveness over four phases of the technology life cycle

Industry Attractiveness–Five Forces

As already established above, the five forces exert different pressures at the different phases of the technological evolution cycle. In this section, we explore the role of each of these forces at each phase and the kinds of strategies that can give a firm a competitive advantage. We start at the beginning of the industrial innovation cycle: the fluid phase.

Fluid Phase

Since products are highly differentiated and serve niche markets, *rivalry among existing competitors* is not as high as in the specific state. As more new entrants enter, however, even the niches may become crowded increasing rivalry. If the technological discontinuity that ushered the fluid phase destroys the competences and firm-specific assets that incumbents had accumulated in the specific phase, the *threat of new entrants* is very high. Given the technological and market uncertainties, incumbents cannot take some of the measures that they would take in more stable conditions to keep out new entrants. For example, making irreversible commitments in capacity or staking out product market positions is more difficult since uncertainty on what markets to serve or

products to develop still looms large. The *bargaining power of suppliers* is low since materials and equipment are general-purpose. The *bargaining power of customers* is also moderately high since the products they buy are highly differentiated and many customers may be lead users. The *threat of substitutes* comes largely from the old technology that is being replaced by the new. As Utterback and Kim (1986) have shown, some of the best innovations in the older technology have come when the threat of the invading technology is becoming a reality. The effects of the five forces on the manufacturer are summarized in Table 1.

Strategies

The firm has two kinds of strategies: one earmarked towards the present phase, and the other to position the firm well for the next phases. For the fluid phase, the firm could take advantage of the prevalence of product innovations to offer niche products. In anticipation of the transitional phase where the dominant design is expected to emerge, the firm can invest in helping its own design emerge as a standard or the dominant design. Such efforts are particularly useful for products where network externalities are important; in fact, so useful that the firm still stands to benefit even if its product does not become the standard (Garud and Kumaraswamy, 1993). For example, Sun Microsystems' hassle-free licensing of its SPARC technology to anyone who wanted it may have helped its position in the RISC workstation business (Khazan and Mowery, 1992). In anticipation of the specific phase, the firm can also invest in intensive patenting to protect its intellectual property.

Force	*Pressure in the Fluid Phase*
Rivalry among existing competitors	• Low since products are highly differentiated and often unique • May be increases by campaigns to win the dominant design of the transitional phase
Threat of new entrants	• High. Given high market and technological uncertainty, it is difficult to erect barriers to entry. • Threats from alternate technologies with comparable price/performance
Bargaining power of suppliers	• Low since materials and equipment used are general purpose
Bargaining power of customers	• High since products are still unique and most users are lead users
Threat of substitutes	• High, especially from old products that are still viable substitutes in many applications
Some strategies	• Focus on niche products • Emphasize patenting • Invest to try and influence the dominant design of the transitional phase

Table 1: Industry attractiveness at the Fluid Phase

Transitional

With the emergence of a dominant design, many of the product and market uncertainties of the fluid state are reduced. This results in more *rivalry among existing competitors* as the "winners" of the dominant design scramble to win new customers with a product that is less differentiated than at the fluid phase. With product innovation giving way to process innovation, firms scramble to invest in capacity, and advertising and other measures designed to signal commitment to specific market positions in preparation for entering the specific state. The *threat of new entrants* is high since product and market uncertainties have been reduced with the emergence of a dominant design and better defined markets. The *bargaining power of suppliers* increases (compared to the fluid state) since the equipment and materials are now more specialized. Since the emergence of a dominant design allows for differentiated but not unique products, the *bargaining power of customers* increases. The *threat of substitutes* becomes higher since the products being sold are less niche than at the fluid state. These effects are summarized in Table 2.

Force	*Pressure in the Transitional Phase*
Rivalry among existing competitors	• Low but the emergence of a dominant design increases rivalry
Threat of new entrants	• Differentiated products assure some level of protection from new entrants but threat increases with the emergence of standard or dominant design. • Low if "winners" of dominant design keep technology proprietary • High if "winners" of dominant design license technology generously
Bargaining power of suppliers	• Higher than in the fluid phase since materials and equipment become more specialized
Bargaining power of customers	• Higher than in the fluid phase since products are no longer unique
Threat of substitutes	• Higher than at the fluid phase as products become more standard
Some strategies	• Focus on differentiated products • Make irreversible investments in capacity, brand advertising, and process R&D in preparation for specific phase. • Contract with suppliers for equipment or specialized materials that will be needed in the specific phase.

Table 2: Industry Attractiveness at the Transitional Phase

Strategies

Strategic alliances or licensing policies could help the firm win or consolidate the dominant design. The firm can start preparing for providing low cost products in the specific state by making

irreversible investments in capacity, process R&D, and advertising to establish brand name recognition. It can also locate and acquire intellectual property rights or enter special contracts with suppliers for key factors of production.

Specific Phase

In the specific phase, competition is oligopolistic with a few firms that produce commodity products from a dominant design. The forces exerted on a firm in an industry are shown in Table 3. *Rivalry* among these firms is high given the commodity nature of the products they sell. Competition uses such tools as incremental product or process innovations. For example, some automobile makers have used such incremental product innovations as electronic fuel injection, anti-lock brakes, all wheel drive and air bags to try to gain an advantage. The rate of such innovations, and therefore of the amount of rivalry, is also a function of such environmental factors as how demanding customers or government regulators are (Porter, 1990, Thomas, 1992). An incumbent can also stake out a product market position by making non-reversible investments in capacity or advertising thus signaling to rivals that any entry into its product-market space will be met with retaliation (Schmalensee, 1983; Ghemawat, 1991). For example, a computer memory chipmaker who invests $1.3 billion to build a manufacturing facility in Utah signals to its competitors that it will be in that market for computer memory chips for the long haul. Incumbents can also use a radical innovation to fight their rivals . (More on this shortly.)

Force	*Pressure in the Specific Phase*
Rivalry among existing competitors	• High because of the commodity nature of products • Can be reduced by such things as tacit collision
Threat of new entrants	• Low because of measures such as: irreversible investments in capacity, brand name, patents, special licenses or contracts and distribution channels; reputation for retaliating. • There may also be a threat from alternate technologies with better price/performance.
Bargaining power of suppliers	• High for major suppliers of specialized materials and equipment who are also sources of innovations, especially process innovation.
Bargaining power of customers	• Higher since product is more or less a commodity
Threat of substitutes	• High especially form invading technologies.
Some strategies	• Focus on low cost • Emphasize quality • Signal commitments by advertising, investing in capacity and R&D.

Table 3: Industry Attractiveness at the Specific Phase

Several factors reduce the *threat of new entrants* who want to use the prevailing technology to enter. In the first place, incumbents may have certain advantages over new entrants. For example, they may have licenses and patents that give them exclusive access to complementary technologies, supplies or special distribution channels. They may also be further along the technology learning curve or have established brand names and reputations through prior advertising and performance. In the second place, incumbents may exhibit certain characteristics that signal new entrants that they will fight entry by, say lowering their prices. For example, incumbents with high irreversible investments in firm-specific assets, excess capacity, or a reputation for retaliating against new entrants are likely to keep out new entrants from entering their market. If an incumbent has high exit costs, it is also more likely to fight to stay in the industry than one without. The biggest threat, therefore, comes from new entrants that are using an invading technology that can render incumbent competences and firm-technology-specific assets obsolete. For example, electronic cash registers rendered NCR's competences, and irreversible investments in capacity and service centers obsolete. This allowed Singer to use electronic cash registers to invade the electromechanical cash register market.

The *threat of substitutes* is mostly from new technologies although in some cases it may be from so-called generics when, for example, an incumbent's patent has expired. On the other hand, the *bargaining power of suppliers* is high since they supply specialized equipment and materials, and are a major source of innovations. So is the *bargaining power of customers* since products are more or less commodity. In both cases, the bargaining power can be reduced by collusion on the part of rivals.

Strategies

A firm has two kinds of strategies it can pursue: one type targets the present phase and the other, the next phase(s). For the specific phase, the firm could maintain a low cost strategy given that the products being sold are largely undifferentiated commodities and most innovations are process innovations earmarked for cost reduction. Some product differentiation is possible but more a matter of positioning. For example, Honda positioning the Acura brand cars in a more luxury bracket than the Honda brand. Mass customization can also give a firm an advantage (Pine, 1993). The firm can also make irreversible investments in capacity or build a reputation for retaliation to signal to rivals and new entrants alike to stay out of its product-market positions. Since the biggest threat is that of an invading technology that will take the firm into the fluid state, the firm can scan possible invading technologies and develop dynamic capabilities (Teece, Pisano, and Schuen, 1992) so that it can adjust very quickly in the event of a technological discontinuity.

Discontinuities

A technological discontinuity usually renders the old technology non-competitive, and many of the barriers that firms may have erected around them in the specific phase may become useless. Irreversible investments in plant capacity and R&D, special licenses, contracts for special materials or services may become obsolete. For example, the arrival of electronic cash registers destroyed a lot of the barriers to entry such as specialized plants, excellent service networks, investments in R&D for electromechanics, patents, and other intellectual property that NCR had accumulated in exploiting electromechanical cash registers. Technological discontinuities normally level the playing ground although they can be a handicap to incumbents (Cooper and Schendel, 1976; Scherer, 1992; Foster, 1986; Utterback, 1994) and set the stage for the rest of the cycle.

The impact of a discontinuity on industry attractiveness is summarized in Table 4. The *threat of new entrants* is high since the playing ground has been leveled and the fear of cannibalizing old products may actually place incumbents at a disadvantage (Reinganum, 1982, 1984). The *threat of substitutes*, from the new technology is now very high. *Rivalry* among incumbents is not high since they are still trying to exploit the old technology. The *bargaining power of suppliers* and customers is uncertain since market needs and supplier requirements are very uncertain.

Strategies

Strategies at a discontinuity can be targeted largely towards preparing for the fluid phase. Such strategies may include identifying lead users (von Hippel, 1988) who will be critical when the firm has to determine just what market needs are and how to meet them.

Force	*Pressure in the Discontinuity Phase*
Rivalry among existing competitors	• Low or high depending on the reaction of incumbents
Threat of new entrants	• High since new entrants can use the new technology to enter
Bargaining power of suppliers	• Low since their specialized materials and equipment being replaced soon by general purpose materials and equipment.
Bargaining power of customers	• High since discontinuity leads to fluid phase with its unique products
Threat of substitutes	• High
Some strategies	• Take necessary steps to identify lead users

Table 4: Industry Attractiveness at the Discontinuity Phase

Firm Competences And Resources

In the first part of this section, we explored industry attractiveness at each phase of industry evolution, the kinds of products that can be offered, and some corresponding strategies. The capabilities that a firm needs to be successful also vary from one phase to the other, given the differences in the critical success factors. Since firms within an industry have different capabilities that allow them to earn different levels of economic rents (Cool and Schendel, 1988; Rumelt, 1991; Nelson, 1991), an industry's attractiveness to a firm is also a function of the extent to which the firm's competences and firm-specific assets match the levels that are needed to be successful in the industry. The strategy process then consists of [following the determination of industry attractiveness as outlined above): 1) Determining what kinds of product-, supplier-, complementary innovator- and customer-focused competences and resources are necessary to stake out a profitable market position (low cost or product differentiation) for that particular industry at each phase of the industrial innovation cycle. 2) Examining the firm's own competences and resources to see to what extent they can allow the firm to compete in the industry at the phase in question. 3) Since unique capabilities take time to build, establishing strategies at each phase to build competences and firm-specific assets for that phase and the next one(s).

Fluid Phase

Since the early growth of an industry is characterized by very high market and product uncertainty, competences that allow the firm to make some sense out of chaos can be invaluable in this phase. Customer-focused competences such as the ability to communicate well with customers and help them identify their needs can be invaluable. The ability to work with lead users may be particularly important (von Hippel, 1988). Obtaining many patents can pay off later in the transitional phase, especially if the firm's design emerges as the standard. Even if the firm loses the dominant design, its patents can still be useful as bargaining chips in the efforts to adopt the dominant design.

Since the phase is usually ushered by a competence-destroying technological change requiring completely new skills, knowledge and abilities (Utterback and Abernathy, 1975; Tushman and Anderson, 1986; Tushman and Rosenkopf, 1992), there may be some problems unique to incumbents. An incumbent's history—especially the competences and firm-specific assets acquired in the specific phase of the previous technology—play a vital role in where it searches for the new technological information and the kinds of decisions that it takes (Prahalad and Bettis, 1986; Henderson and Clark, 1990; Bettis and Prahalad, 1995). Thus an incumbent's perception of the attractiveness of an industry may be greatly tainted by its history. For example, NCR saw the invading cash registers as only a faster way of adding numbers. It did not see them as a new tool for its customers to better manage their inventories and supplier-relations.

Incumbents may have to unlearn most of what made them so successful in the specific state of the previous technology (Bettis and Prahalad, 1995). Firms with dynamic capabilities (Teece, Pisano and Schuen, 1992) also do well in the switch since they can very quickly develop the capabilities that they need to compete in the present technology. Project management skills can be useful given the amount of experimentation that has to be carried.

Skilled engineers such as "gurus' or "renegades", especially from the source of the technological innovation being adopted can be very useful. Examples of the types of competences and resources required to perform well at the Fluid phase are shown in Table 5.

Type of Capability	*Examples*
Product -focused	*Competences* • Project management skills • Ability to patent • Ability to unlearn old competences and acquire new ones • Ability to make sense out of chaos *Resources* • Guru engineers from parent technology company • Diverse entrepreneurial organization
Supplier-focused	*Competences* • Ability to work with suppliers to modify general purpose equipment to meet unique needs • Supplier-relations expertise *Resources* • Investments in supplier-related assets
Customer-focused	*Competences* • Ability to decipher customer needs and translate to products • Ability to make sense out of customer feedback *Resources* • Experience marketing function • Reputation
Complementary Innovator-focused	*Competences* • Ability to communicate with complementary innovators to understand how they can provide complementary products *Resources* • Reputation • Prior relationships
Strategies	• Focus on key customers, especially lead users, and their needs • Build technical competences, project management skills and resources such as patents.

Table 5: Competences and resources needed to succeed in the Fluid Phase

Strategies

Building customer-focused capabilities can aid efforts to better understand customer needs and what the product should look like. In some industries, it may pay to patent fiercely to use as a bargaining chip later in product development after the dominant design emerges in the transitional

phase. Formulating a licensing strategy at this phase may help in the battle in the transitional phase to win the dominant design.

Transitional

The emergence of a dominant design greatly reduces both product and market uncertainties and suggests the need for competences that are different from those of the fluid phase. Whereas, in the fluid phase, the focus was on those capabilities that allow one to determine what features to include in the product, in the transitional phase, the attention shifts to how to improve the values of those features. There is a shift from major product innovations to process innovations and a corresponding shift in skills. As materials and equipment become more specialized the need for supplier-focused competences also increases. As products are no longer niche but differentiated, the need for customer-focused competences also increases.

Type of Capability	*Examples*
Product -focused	*Competences* • Ability to design products that meet customer needs • Ability to know where to make irreversible investments *Resources* • Design experience
Supplier-focused	*Competences* • Ability to negotiate contracts for specialized materials and equipment that are needed in the specific phase *Resources* • Reputation for being a good customer
Customer-focused	*Competences* • Ability to synthesize emerging customer needs • Ability to develop installed base, distribution and service networks *Resources* • Installed base
Complementary Innovator-focused	*Competences* • Ability to build network of complementary innovators *Resources* • Reputation • Special agreements to develop complementary products
Strategies	• Focus on skills for product differentiation • Focus more attention on marketing than in the fluid phase • In preparation for specific phase, advertise to establish brand recognition

Table 6: Competences and resources needed to succeed in the Transitional Phase

A strong reputation in related technologies or products may be invaluable. For example, IBM's reputation in mainframes and minicomputers was instrumental in making its PC the standard. Existing patents, licenses and agreements can be invaluable in the maneuvering for a dominant design. Examples of the types of competences and resources that a firm must have to perform well at the transitional phase are shown in Table 6.

Strategies

Prior to the emergence of the dominant design, strategic maneuvering such as detailed by Cusumano, Mylonadis and Rosenbloom (1992) in the case of VHS emerging as the standard for video tape recording can be valuable. Building of customer-and supplier-focused competences may also be valuable given the switch from using of generic supplies to more specialized ones.

Specific Phase

Since products are largely commodity in the specific phase, emphasis is on those competences and firm-specific assets that allow a firm to produce at low cost and profit from it Low costs are attained largely through process and incremental product innovations. Special licenses or patents that give a firm unique access to low cost processes can be invaluable. The source of process innovations is often major suppliers of specialized equipment who, in this phase, have high bargaining power. Special contracts, unique supplier-relations or special skills in dealing with such suppliers can be important. Close supplier relations that allow for co-development of components or close monitoring of incremental innovations from suppliers can also be valuable. Low cost and some product differentiation can also come from incremental product innovations. Such incremental innovations, by definition, require skills that build on existing competences and resources. This gives incumbents an advantage since they already have the competences and firm-specific assets to build on for incremental innovations. Some innovations which masquerade as being incremental, however, may actually be architectural and can present firms that view them as incremental with problems (Henderson and Clark, 1990).

Given that the bargaining power of customers and rivalry among existing competitors are high, a firm's customer-focused competences and firm-specific assets can be particularly valuable. For example, a firm's brand names, reputation for high quality products, networks of service centers, distribution channels, user networks, and ability to synthesize customer needs into product attributes and a language that product developers can implement technologically are invaluable. Examples of the types of competences and resources required to perform well at the specific phase are shown in Table 7.

Strategies

As we show shortly, all these acquired competences and firm-specific assets can become a handicap in the face of a competence-destroying technological discontinuity. Thus the biggest challenge to a firm in the specific phase is balancing the act of exploiting the old technology while getting ready for the inevitable arrival of the new one (Tyre and Hauptman, 1992). Strategies in this phase are focused on preparing for the discontinuity and fluid states. The Teece, Pisano and Schuen (1992) model of dynamics capabilities is particularly applicable here.

Type of Capability	*Examples*
Product -focused	*Competences* • Design for manufacturability • Fast turn around times • Process and incremental innovation expertise *Resources* • Patents and other intellectual property • Special licenses for low cost processes • Gate keepers and boundary spanners
Supplier-focused	*Competences* • Ability to integrate innovations from supplier to own processes *Resources* • Special contracts for materials or equipment
Customer-focused	*Competences* • Ability to sell • Ability to create new distribution channels *Resources* • Experienced sales force • Distribution channels, and service networks • Reputation
Complementary Innovator-focused	*Competences* • Ability to co-ordinate innovations with complementary innovators *Resources* • Reputation • Special agreements to develop complementary products
Strategies	• Focus on competencies that assure low cost and profitability from it • Boost process innovation and incremental product innovation skills • Scan and prepare for invading technologies

Table 7: Competences and resources needed to succeed in the Specific Phase

Discontinuities

It usually takes a technological discontinuity to move from the specific phase of one technological evolution cycle to the fluid phase of the next cycle (Utterback, 1994). A technological discontinuity can be competence-enhancing if the capabilities required to exploit it build on those used to exploit the previous technology (Tushman and Anderson, 1986). Such a discontinuity would tend to perpetuate the oligopolies of the specific state. If, however, the technology is competence-destroying in that the capabilities required to exploit it are significantly different from existing ones, then a firm's accumulated competences and resources may not only useless, they may actually constitute a handicap for the firm (Henderson and Clark, 1990; Henderson, 1993). In any case, the first step in coping with or taking advantage of a technological discontinuity is to recognize the potential or threat that the new technology poses early enough to take appropriate action (Afuah, 1994).

A competence-destroying technological innovation usually levels the playing field but incumbents (from the oligopoly of the specific phase) may be shackled by the competences and resources that had been a source of competitive advantage in the specific phase. The technological

change may not obsolete all of an incumbent's capabilities to exploit it. For example, Mitchell (1989, 1991, 1992) has shown that if the discontinuity obsoletes only product-focused competences and resources, leaving market competences and market-specific assets intact, then incumbents have an advantage. Similarly, if supplier-focused capabilities are left intact in industries where supplier relations are important, incumbents may also have an advantage. Thus a firm's ability to recognize just which of its capabilities will be obsoleted by the arrival of a technological discontinuity and to build those capabilities while taking advantage of those capabilities that are not impacted by the technology can also be an asset.

Type of Capability	*Examples*
Product -focused	*Competences* • Ability to recognize the threats and potential of new technologies early. *Resources* • Outstanding gatekeepers and boundary scanners • Close relationships with universities and other public research institutions
Supplier-focused	*Competences* • Ability to recognize supplier-originated innovations *Resources* • Trusting supplier relations
Customer-focused	*Competences* • Ability to make discontinuities transparent to customers • Ability to recognize customer-originated technological discontinuities *Resources* • Experience marketing and sales forced
Complementary Innovator-focused	*Competences* • Ability to make discontinuities transparent to complementary innovators *Resources* • Reputation • Large compatible installed base
Strategies	• Focus on recognizing the potential threats and opportunities of the discontinuity • Unlearning of old skills by incumbents is critical

Table 8: Competences and resources needed to succeed in the Discontinuity Phase

In some cases, the technological discontinuity may also obsolete the competences of suppliers, customers and complementary innovators (Afuah and Bahram, 1995). Thus the ability of the manufacturer to limit the extent to which customer and complementary innovator competences are impacted by technological discontinuity is a valuable competence in itself. The impact of a discontinuity on the competences and resources of a firm are summarized in Table 8.

Strategy

It is important to focus on recognizing the potential of the threats and opportunities that the discontinuity presents. Additionally for incumbents, the primary focus is on unlearning the old knowledge so that it may not be a handicap in exploiting the new (Bettis and Prahalad, 1995). In

anticipation of the fluid state, a firm may also start acquiring the skills that it needs to cope with the rapid rate of product innovations of the fluid phase. Quinn (1992) suggest that in this state, a firm should look at its portfolio of competences to see which ones best fit the new technology.

4. SUMMARY AND CONCLUSIONS

We proposed a dynamic strategy model based on a technological evolution perspective which suggests a link between the product-market position and the resource-based views of competitive advantage. Drawing on the Utterback and Abernathy (1975) dynamic model of innovation, the Utterback (1994) model on the dynamics of innovation among multiple productive units, and other models of technological and industry evolution, we argued that the technologies which underlie low cost, product differentiation, and firm heterogeneous capabilities evolve over time as the firms exploiting them interact with their environments. As technology evolves, so do industry characteristics and critical success factors. The evolution determines what kinds of products (niche, differentiated or low cost) can be offered at each of the phases. Firms that do not have the capabilities to offer these products, may be forced to exit. Thus an industry's attractiveness and the kinds of capabilities that a firm needs to succeed, may also vary from phase to phase suggesting different strategies for each phase. A firm's strategies and heterogeneous capability in one phase, depend on its strategy, and capabilities in the previous phase(s).

With this background information, we proposed a dynamic competitive model. In the model, we argued that since industry structure and critical success factors change as the underlying technology evolves from phase to phase, the competitive pressures exerted on a firm necessarily vary. Moreover, since only certain products can be offered at each phase and firm capabilities are unique, an industry that is attractive to one firm may not be to another. Based on these arguments, we proposed a three-step process for analysis: First, at each of the four phases of the industrial innovation cycle, the firm analyzes the pressures being exerted by Porter's (1980) five forces to determine the industry's attractiveness. Second, the firm evaluates the extent to which its competences and resources meet the levels and quality needed to successful offer products at each phase. Finally, at each phase, the firm takes strategic steps that also anticipate the nature of the next phase(s).

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