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STRATEGIC FLEXIBILITY IN PRODUCT COMPETITION

RON SANCHEZ
College of Commerce and Business Administration, University of Illinois at Urbana–Champaign, Champaign, Illinois, U.S.A.

This paper investigates competition in dynamic product markets from combined resource base and strategic flexibility perspectives. A concept of strategic flexibility in product competition is developed in which flexibility depends jointly on (1) the resource flexibility *of the product creation resources avaialble to a firm and (2) the* coordination flexibility *of the firm in using its available resources in product markets. Two recent* technological innovations *affecting product creation processes—CADD/CIM systems and modular product design—are argued to have greatly increased the potential flexibilities of key product creation resources.* Managerial innovations *in the use of these technologies have also led to important new coordination flexibilities. The combination of recently achievable resource and coordination flexibilities is argued to have* transformed the competitive environments *of many product markets, leading to new kinds of product strategies, new organizational forms, and a* new dominant logic *for competing in dynamic product markets.*

COMPETITION IN DYNAMIC PRODUCT MARKETS

In the last decade, new patterns of product competition have emerged and, in some cases, become dominant in markets for personal computers, consumer electronics, financial services, computer software, and a growing number of other products. These new patterns of competition appear to reflect significant new *flexibilities* of some firms to respond more quickly than ever before to changing technological and market opportunities by introducing more new products, offering broader product lines, and upgrading products more rapidly. Further, many of these newly flexible product creators are capable of more finely segmenting product markets and offering well-differentiated products to a larger number of market segments at prices that are often competitive with standard products.

The presence of one or more firms with superior flexibility to sustain elevated rates of broadly targeted product creation precipitates a dynamic market environment in which product life cycles become shorter and highly uncertain. Moreover, the new patterns of product competition often initiated by firms with superior flexibilities in product creation can be highly destabilizing to firms that try to adhere to more traditional product strategies of low cost, differentiation, or focus.

New patterns of product competition

Researchers investigating dynamic product markets have noted several striking patterns of product competition, four of which are presented here as stylized facts describing these new competitive environments.

Key words: strategic flexibility; resource flexibility; coordination flexibility; managerial innovation; technological innovation; dominant logic

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Real-time market research

Some firms appear to make little or no use of traditional marketing research methods to guide their product creation strategies. Instead, they engage in new forms of market research by testing markets with 'learning models'—actual production models manufactured and marketed in small lots. Such firms appear to have achieved sufficiently low costs and high speed in developing and producing new products that they can use 'real-time market research' methods (Sanchez and Sudharshan, 1992) to bypass traditional methods in favor of directly assessing the reactions of actual customers to real products. In introducing its Walkman product to the U.S. market in the 1980s, for example, Sony was able to introduce more than 160 Walkman variations in rapid succession (Sanderson and Uzumeri, 1990) and thereby to accelerate its learning about consumer preferences for its new product concept.

Rapid product proliferation

Once a flexible product creator discovers a particularly profitable product market, it may quickly commercialize a large cluster of related product models to saturate the product market. Flexible product creators may thereby be able to preempt the most profitable markets and prevent entry by less flexible product creators. In the U.S. market for Walkman-like products, Sony and its Aiwa subsidiary together produced more than 250 models of Walkman and Walkman-like products in the 1980s, leaving relatively few market opportunities for Matsushita and other competitors to position their Walkman clones (Sanderson and Uzumeri, 1990). After previously ceding major market share to Matsushita in consumer electronics markets like televisions and video cassette recorders, Sony was able to use high rates of well-targeted new product introductions to capture and defend a strong 40 percent share of the world market for the Walkman product concept it pioneered (Meyer and Utterback, 1993).

Intensive market segmentation

Flexible product creators may also produce product variations very early in the evolution of a new product market to deepen their understanding of customer preferences. They may then use that knowledge to create differentiated products precisely tuned to the preferences of specific market segments. Some analysts of product-based competition suggest that in a growing number of product markets product differentiation at the level of market segments will be replaced within the next few years by *mass customization* of products for targeted customer groups (Pine, 1992) or even by *product personalization* for individual consumers (Sanchez, 1994a). Evidence of these developments already exists; some Japanese automobile makers are offering mass-customized cars targeted at groups of only 20,000 customers, National Bicycle Corporation is already mass-personalizing bicycles for Japanese consumers (Kotha, 1995), and U.S. publishers are offering business school professors 'customized textbooks' composed of cases, texts, and notes selected by each professor to convey her or his personal preferences for teaching a subject.

Rapid performance improvement

Some firms have product creation flexibilities that let them rapidly introduce technological improvements into their products, often voluntarily obsoleting their own market-leading products *before* competitors introduce comparable products. By aggressively cannibalizing their own products (Conner, 1988) through *early obsoleting* of successful models, these firms challenge competitors to match the speed and cost effectiveness of their trajectories for rapid product upgrading. Flexible product creators use this product strategy to deny both fast followers and product imitators prospective windows of opportunity in which to earn profits. This product strategy may *preempt* a product market when competitors decline to enter or remain in a product market in which they cannot keep pace in upgrading products. Sony provides an example of this pattern of product competition with its rapid introductions of five technologically upgraded HandyCam video camera models between December 1981 and October 1983 (Sanchez, 1991).

Transformation of technology, strategies, organizations, and environments

Since Chandler's landmark study (1962) of the emergence of the multidivisional corporation as an innovative organizational form, the interrelationships of firm strategies, organization structures, and competitive conduct have commanded substantial attention in strategy research. Research into the 'strategy–structure–conduct' relationship, however, sometimes overlooks two essential features of this relationship. First, strategy–structure–conduct relationships occur within a *technological context* that constrains a firm's feasible choices; changes in available technologies may result in changes in feasible sets of strategy, structure, and conduct.[1] Second, the causal flow between the technological context and strategy–structure–conduct relationships is not unidirectional. Changes in strategy–structure–conduct relationships made possible by technological changes may suggest further technological changes that could lead to more advantageous strategies, structures, and conduct.

This paper proposes that two sets of related innovations—one *technological* and the other *managerial*—are jointly creating an escalating process of change that is rapidly diffusing and transforming competition in a growing number of product markets:

1. Recent *technological innovations* affecting the development and production of products have radically increased the *flexibilities* in product creation processes, making possible an acceleration of product creation processes.
2. *Managerial innovations* in devising new product strategies and new organizational forms have enabled some firms to be more effective in strategically exploiting the flexibilities of the new technologies in developing, producing, and marketing products.

When used in concert, these technological and managerial innovations are transforming many product markets into highly dynamic competitive environments in which rapid new product creation fuels new patterns of product competition. Moreover, as diffusion of these flexible product creation technologies causes product markets to become more dynamic and competitive, demand for these technologies stimulates further technological development. Thus, as suggested by the positive feedback loop in Figure 1, the dynamic process driving the ongoing transformation of competitive environments is a 'virtuous circle' of change based on increasing flexibilities of new product creation technologies, product strategies, and organization structures.

In product markets like personal computers and consumer electronics, where the flexibilities of new product creation technologies are commonly used, aggressive new product strategies provide differentiated products at competitive prices. In these product markets, fluid new organizational forms of network-based product creation are resulting in highly dynamic competitive environments. Moreover, similar managerial innovations in product strategies and organizational structures that make effective use of flexible product creation technologies have occurred in product markets as diverse as airliners, automobiles, software, household appliances, housewares, power tools, and financial services (Sanchez and Mahony, 1994). Thus, the transformation of competitive environments caused by these technological and managerial innovations is not a sectoral phenomenon applicable only to 'high-tech' product markets.[2]

STRATEGIC FLEXIBILITY IN PRODUCT COMPETITION

Although many forms of technological change are now evident in product markets, this article focuses on the effects of the diffusion of new product creation technologies on product strategies and organizational structures. To investigate these relationships, this article uses a *strategic flexibility* perspective (Sanchez, 1993)

[1] A central theme in Chandler's work (1962, 1977) is the impact of *technological changes* in transportation (railroads), communication (telegraph), and information processing (cost accounting methods) on the competitive strategies and organization structures firms could feasibly adopt. Chandler also observed that changes in technologies suggested new possibilities for strategies and led to searches for new organizational structures to carry out those strategies. He also noted that experience with new organizational structures appeared to suggest new possibilities to managers for further innovations in technologies and in competitive strategies that could more fully realize the potential of new technologies applied through new organization structures.

[2] The extent to which the interrelated technological and managerial innovations discussed here can be applied may vary across industries. Firms within industries are also likely to differ in their abilties to use new technologies to achieve simultaneous low-cost production and product differentiation (Nayyar, 1993) and other synergies.

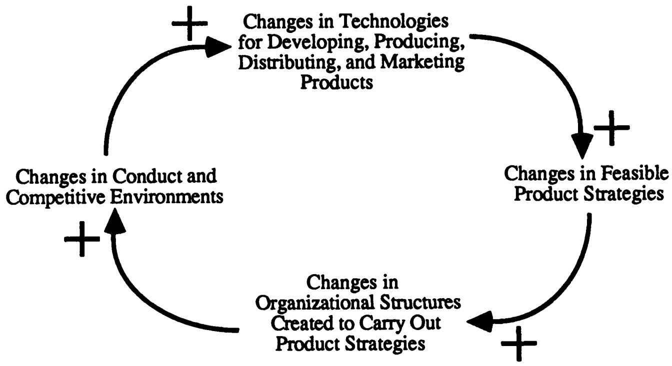

Figure 1. Systemic relationships and positive feedback among technologies, product strategies, organization structures, and competitive environments.

and a resource-based view of competition (Wernerfelt, 1984; Dierickx and Cool, 1989; Barney, 1991; Grant, 1991; Peteraf, 1993) to develop concepts of *resource flexibility* and *coordination flexibility* in product competition. The concept of resource flexibility illuminates the impact of new product creation technologies on resources for developing, producing, distributing, and marketing products. The concept of coordination flexibility helps identify critical interdependencies between the flexibilities in a firm's product creation resources and the firm's ability to apply those resources effectively through new product strategies and organizational structures.

Strategic flexibility

The term *strategic flexibility* has been widely used by strategy researchers to denote firm abilities to respond to various demands from dynamic competitive environments. Accordingly, research on strategic flexibility has ranged from empirical investigations of the relative flexibilities of alliances and vertically integrated firms to manage demand volatilities (Harrigan, 1985) to conceptual assessments of the degrees of freedom to do things differently available to managers in high-technology product markets characterized by 'products, manufacturing processes, markets, distribution channels, and competitive boundaries [that] are in a state of continuous flux' (Evans, 1991: 69 and 77).

The concept of strategic flexibility in product competition represents a fundamental approach to the management of uncertainty (Sanchez, 1993). Dynamic product markets are characterized by high levels of uncertainty about the future strategic value of specific resources that are not reducible in the near term. Thus, choosing a single 'best' plan of action likely to be successful is often an unrealistic strategic objective. In dynamic environments a firm can achieve competitive advantage by creating strategic flexibility in the form of alternative courses of action—or *strategic options*—available to the firm for competing in product markets (Sanchez, 1993: 254–255).

Edith Penrose, whose perception of a firm as a 'collection of productive resources' (1959: 24) is a cornerstone of the resource-based view of the firm, emphasized that 'it is never *resources* themselves that are the "inputs" in the production process, but only the *services* that the resources can render' (1959: 25, emphasis in original text). The services of resources are obtained through resource *use*, and a firm's strategic flexibility (i.e., its set of strategic options), therefore, is constrained by the ways in which a firm can use available resources. Strategic flexibility, thus, depends *jointly* on the inherent flexibilities of the resources available to the firm and on the firm's flexibilities in applying those resources to alternative courses of action. As a result, key challenges to strategic managers in dynamic product markets are (1) to identify and acquire the use of *flexible resources* that can give a firm strategic options to pursue alternative courses of action in responding to developments in its competitive environment, and (2) to develop *flexibility in coordinating* the use of resources to maximize the flexibilities inherent in the resources available to the firm (see Figure 2).

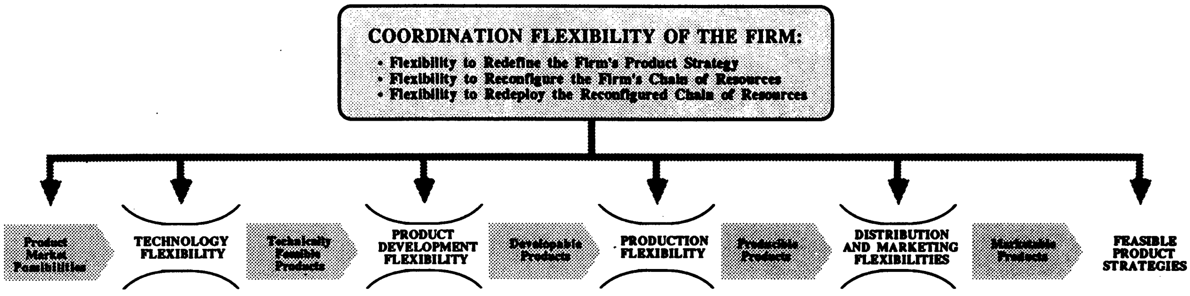

Figure 2. Resource flexibility and coordination flexibility determine feasible product strategies.

Resource flexibility

Resource flexibilities can be characterized through three dimensions of resource 'use' applicable to product competition:

1. Resource flexibility is greater when *there is a larger range of alternative uses* to which a resource can be applied. In the context of product competition, this dimension of resource flexibility reflects the range of different products which a resource can effectively be used to develop, manufacture, distribute, or market.
2. Resource flexibility is greater when *the costs and difficulty of switching* from one use of a resource to an alternative use (i.e., from one product to another) *are lower*.
3. Resource flexibility is greater when *the time required to switch* to an alternative resource use (i.e., from one product to another) *is lower*. Implicit in this dimension of flexibility is an opportunity cost of delay in responding to product opportunities.

As suggested in Figure 2, the flexibility of a product technology resource is provided by the range of possible products than can be derived from the technology. Similarly, the flexibility of a product development resource is based on the range of product possibilities it can feasibly develop, as well as the cost and time to develop each new product. The flexibilities of production, distribution, and marketing resources can be assessed along similar dimensions. Moreover, because the flexibility of each product creation resource constrains the ability of a firm to fully utilize its other product creation resources, the strategic flexibility of a firm to pursue a range of product strategies depends on the flexibilities of *all* the firm's product creation resources. In other words, the *inflexibility* of a firm's least flexible product creation resource limits the flexibility of the firm's overall product creation process—and thus its product strategy options.

Some of the interdependencies among product creation resources have been noted in the literature, including those between production flexibilities and product strategies (Wheelwright and Hayes, 1985; Gerwin, 1989), production and marketing flexibilities (Blois, 1985; Jaikumar, 1986), product development and production flexibilities (Hayes, Wheelwright, and Clark, 1990; Clark, Chew, and Fujimoto, 1992), and technological change, manufacturing flexibility, and product strategies (Uzumeri and Sanderson, 1992). However, the *systemic interdependency* among all the flexibilities in a firm's chain of product creation resources determines a firm's strategic flexibility and product strategy options.

Coordination flexibility

Barnard maintained that 'the creative side of organization is coordination' (1938: 256), and Andrews suggested that the essence of coordination is the 'way in which subdivided functions and interests are resynthesized' (1980: 121). In the context of product competition, coordination involves processes that:

1. define the firm's product strategies in terms of which products the firm intends to offer and which market segments it will target;
2. configure chains of resources the firm can use in developing, manufacturing, distributing,

and marketing its intended products to targeted markets;
3. deploy (i.e., 'resynthesize') resources through organizational structures that support the firm's product strategies.

Analogously, in dynamic product markets that require frequent adjustments in product strategies, flexibility in coordinating the uses of product creation resources consists of flexibilities to *re*define product strategies, *re*configure chains of resources, and *re*deploy resources effectively. Moreover, as suggested in Figure 2, the *coordination flexibility* of the firm to pursue alternative product strategies depends on achieving concurrent flexibilities in all three processes.

TECHNOLOGICAL TRANSFORMATIONS OF RESOURCE FLEXIBILITIES

Resources for creating products consist of specific human, physical, and information assets. This section examines ways in which recent changes in information technologies and product design methodologies have transformed the potential flexibilities of human, physical, and information resources used in creating products.

Changes in information technologies

Developments in many areas of information technology are now widely recognized to have profound, potentially transformative effects on firm strategies, organization structures, and competitive environments in many industries (for a recent overview, see Allen and Scott-Morton, 1994). The following discussion addresses the effects of recent advances in CADD (computer-assisted design and development) systems, CIM (computer-integrated manufacturing) systems, and EDI (electronic data integration) on the potential flexibilities of resources for developing, producing, distributing, and marketing products.

CADD systems

Currently available computer-based tools for product design have progressed substantially beyond the computer-assisted drafting (CAD) software developed in the 1970s and the computer-assisted engineering (CAE) software developed in the 1980s (Adler, 1989; Salzman, 1989; Ulrich, 1990). The current generation of CADD systems offers integrated tools for design, engineering, simulation, testing, and rapid prototyping of new product designs. Because current generation CADD systems can perform almost instantaneously many complex interrelated product design tasks that only a few years ago required hundreds of hours of human designer time, CADD systems have radically reduced the costs of creating and evaluating alternative product designs and thus have greatly increased the efficiency and potential productivity of product designers and engineers. The cost and speed improvements of current CADD systems have enhanced their penetration of design-intensive industries (Åstebro, 1992a, 1992b).

Design and engineering. Current CADD systems perform exhaustive design and engineering analyses to assess the feasibility of a part or component design for its intended use. Because CADD systems have automated much of the engineering analyses required in product design, product designers can now concentrate on higher-level design tasks such as overall product configuration (Fox, 1993) and the resolution of aesthetic and technical requirements (Wallace and Jakiela, 1993). In the design of application-specific integrated circuits (ASICs), for example, where the capabilities of CADD systems have advanced most rapidly, high-level 'design languages' provide libraries of available components and algorithms for integrating components within a design that liberate product designers from performing routine engineering tasks (Dubinskas, 1986a, 1986b; Mostow and Barley, 1987; Carroll, 1993). Moreover, in a growing number of industries, CADD systems create electronic '3-D files' of fully specified, three-dimensional product designs that can be used in simulation programs, rapid prototyping, and automated production processes (Hill, 1994).

Simulation and testing. The product design information contained in a CADD 3-D file can be used to perform computer simulations of the performance of individual parts, components, or complete new products under a broad range of use conditions (Whitney, 1988; Port, 1989; Skerrett, 1992; Winter, 1994). *Virtual reality* devices now available allow designers to see and interact with a new product design which exists only as a CADD 3-D file, in many cases eliminating the need for a physical mockup of the product design. Several automobile makers, for example, use virtual reality to design car interiors, in many cases bypassing costly and time-consuming physical mockups (Sawyer, 1994a).

Virtual assembly is a further extension of CADD that simulates the part-by-part assembly of a new product. Boeing Corp. developed a CADD-based virtual assembly system that allowed it to 'assemble' electronically the 3 million parts of its new 777 aircraft, reportedly saving several months of product development time and millions of dollars in mockup costs (Woolsey, 1994). *Dynamic simulation* software allows the simulation of many performance aspects of production systems. Flows of parts and work-in-process in a proposed factory design, for example, can be simulated before deciding on the final configuration of equipment for the new plant (Schulz, 1994; Hill, 1994). Black & Decker Co. now routinely simulates proposed production systems to assess their ability to respond to variations in demand and to other production contigencies before deciding on a plant configuration (Cosco, 1994).

Rapid prototyping. New technologies have also been developed for *rapid prototyping*, which allows individual parts and pieces of a product design to be fabricated in a few minutes by machines controlled directly from CADD design files (Ashley, 1991; Schrage, 1993; Stevens, 1993; Wall, Ulrich, and Flowers, 1992). Some firms now make extensive use of CADD-derived prototypes to elicit reactions to proposed new product designs from targeted customers or parts suppliers (Sawyer, 1994b).

These continuing developments in CADD systems are radically increasing the flexibilities of product development resources by drastically lowering the cost and time required to develop new product designs, permitting intensified levels of product creation.

FMS, CAM, CIM, and EDI

A flexible manufacturing system (FMS) is 'a production unit capable of producing a range of discrete products with a minimum of manual intervention' (Office of Technology Assessment, 1984). Among firms in the United States with more than 10,000 employees, 68 percent of electrical equipment manufacturers, 78 percent of machinery producers, 93 percent of automobile makers, and 100 percent of aerospace companies expect to have some form of FMS by the year 2000 (Mansfield, 1993: 154).

Computer-assisted manufacturing (CAM) systems, developed in the 1980s, linked FMS to CAD and CAE systems to allow certain production processes to be driven directly from CAD/CAE product design files. In the 1990s, computer-integrated manufacturing (CIM) systems allow CADD 3-D files to run FMS to make parts and/or to assemble parts into finished products (Gerwin, 1993), enabling a firm to move directly from completing a final product design to production of small lots of samples or even to full-scale production.

Through electronic data interchange (EDI), production scheduling of FMS can be linked 'downstream' to computer-based inventory and ordering systems driven by 'real-time' sales data generated by bar-code scanners or other point-of-purchase (POP) devices, and 'upstream' to suppliers' production systems to assume timely deliveries of parts and components (Davis, 1994; Parker, 1994; *Manufacturing Systems*, 1994). As EDI links CADD, CIM, and POP data into integrated product development, production, distribution, and marketing systems (T. Schulz, 1992; K. Schulz, 1994), information technologies provide software systems that support electronic data integration across the full spectrum of a firm's operations (Parnas, 1972). In the process, new information technologies are radically improving the ability of a firm to discover and respond quickly to new product opportunities.

Changes in product design methodology

Traditional product design methodology involves a search for a single 'constrained optimized' design solution for a product with specified performance objectives and cost constraints (Marples, 1961; Alexander, 1964; Clark, 1985; Ulrich and Seering, 1990). Recently, an alternative design methodology, *modular product design*, has been used in industries as diverse as automobiles, computer hardware, software, photocopiers, consumer electronics, household appliances, test instruments, and power tools (Sanderson and Uzumeri, 1990; Sanchez, 1991; Ghazanfar, McGee, and Thomas, 1992; Sanchez and Mahoney, 1994). The objective of modular product design is creation of a product design that can serve as the basis for a number of product variations with different performance and cost characteristics.

Engineering design methodology typically decomposes an intended product into a hierarchical system of functional components (Simon, 1962; Sanchez and Mahoney, 1994) interrelated through specified interfaces between components that define the physical and functional characteristics of each component (Sanchez, 1994a). The specified component interfaces in a product design define a *product architecture* (Henderson and Clark, 1990; Clark, 1990; Ulrich, 1992; Morris and Ferguson, 1993). One approach to creating a product architecture is to specify *standardized* interfaces between components—i.e., interfaces that are not allowed to change during the development process or perhaps even during the life cycle of the product. Specifying standardized interfaces creates a 'loosely coupled' system of components (Weick, 1976; Sanchez and Mahoney, 1994).

A modular product design results when standardized interfaces in a product architecture are specified to permit *a range of variations* in any given component without requiring changes in the overall product design or in the designs of the other components within the product. *Modular components* are those whose phsyical and functional characteristics are within the range of variations allowed by the product architecture of a modular product design (Stevens, Myers, and Constantine, 1974; Parnas, Clements, and Weiss, 1985; Sanchez 1991, 1994a; Ghazanfar *et al.*, 1992; Sanchez and Mahoney, 1994).

The variations in components that can be accommodated by a modular product design allow more than one, and potentially a great many, versions of modular components to be introduced into a modular product. Thus, a potentially large number of product model variations can be leveraged from a modular product design by 'mixing and matching' different combinations of modular components to create different product models with distinctive bundles of component-based functionalities, features, and performance levels (Sanderson and Uzumeri, 1990; Sanchez and Sudharshan, 1992; Sanchez, 1994a; Baldwin and Clark, 1994). The ready substitution of component variations into a modular product design achieves economies of substitution (Garud and Kumaraswamy, 1993) that allow product variations to be leveraged quickly and at low incremental costs per product variation, greatly increasing the flexibility of product designs.

Technological transformations of resource flexibilities

The diffusion of new information technologies and modular product design methodology have had a profound transformative impact on the potential flexibilities of product creation resources by increasing the range of different products to which a given resource may be applied, by lowering the cost and difficulty of switching a product creation resource from one product to another, and/or by reducing the time required to switch resources between products.

Of all the resources that compose the chain of product creation resources (Figure 2), the new flexibility of production resources has thus far been studied the most intensively. The following discussion extends frameworks for analyzing flexibilities developed in the flexible manufacturing literature to identify analogous forms of flexibilities possible in other product creation resources. Special attention is focused on the effects of modular product design on the flexibilities of product creation resources. Examples are introduced to suggest potential applications of new resource flexibilities in product strategies that lead to new patterns of product competition.

Production resource flexibilities

The integration of new information technology with production machines capable of performing multiple operations on a variety of parts has resulted in production systems with many forms of flexibilities. (For surveys of the manufacturing flexibility literature, see Swamidass, 1989; Sethi and Sethi, 1990; Stecke and Raman, 1995). These flexibilities include process flexibilities and product flexibilities (Beckman, 1990).

Process flexibilities improve the ability of a production system to cope with internal or supply contingencies, such as unexpected machine failures, changes in the routing of a part through the production system, or variabilities in inputs (Buzacott, 1982). Process flexibilities increase the rate and cost efficiency of capacity utilization in the manufacture of a given set of products (Bernardo and Mohamed, 1992; Sinha and Wei, 1992).

Product flexibilities are more relevant to product competition in dynamic markets. Product flexibilities increase the range of products a production system can process and/or reduce the cost and time required to switch production resources from one product to another. Gerwin (1993: 398–400) identified seven forms of production system flexibility, four of which directly affect a production system's product flexibility:

1. *Mix flexibility*: the diversity of a product line which a production system can process without major reprogramming or reconfiguration of the production system. Production systems with high degrees of mix flexibility achieve economies of scope (Lei and Goldhar, 1990) and short lead times while providing a broad range of related products.
2. *Modification flexibility*: the ability to accommodate minor changes in a product design. Modification flexibility improves the ability of a production system to process an upgraded product design or to customize a basic product for a specific customer group.
3. *Changeover flexibility*: the ability to convert a production system from its present product line to another group of products. Changeover flexibility allows a firm to introduce new kinds of products quickly, with low costs of retooling.
4. *Flexibility responsiveness*: the ability of a production system to change its mix flexibility, changeover flexibility, modification flexibility, or process flexibilities. In essence, flexibility responsiveness is the ability of a production system to change its mix of flexibilities at any point in time. Flexibility responsiveness allows machines in a production system to be rearranged in new production lines with new product and process flexibilities.

The following discussion suggests that the product flexibilities of production resources have important counterparts in the flexibilities of development, marketing, distribution, and technology resources.

Development resource flexibility

The output of a product development process is a fully developed product deisgn (i.e., a readily producible product design) and a carefully considered program for producing the designed product (Hayes *et al.*, 1990).

A modular product design methodology creates *flexible product designs* that allow 'mixing and matching' of modular components in a modular design. By leveraging a range of product model variations from a modular product design, a firm can significantly increase the *mix flexibility* of the firm's development resources.

The *changeover flexibility* of development resources can also be increased when modular product designs serve as the basis for leveraging new families of derived product models. In the introduction of its Walkman into the United States in the 1980s, for example, Sony used the mix and changeover flexibilities of its modular product designs to leverage more than 160 Walkman models from five modular designs (Sanderson and Uzumeri, 1990; Sanderson, 1991). General Motors recently adopted a modular product design strategy that leverages its worldwide product families from a matrix of about 100 compatible modular components (engines, drivetrains, major chassis elements, etc.) which can be combined with about 70 different basic body modules (Kacher, 1994).

Changeover flexibility is further enhanced when components can be used in common across more than one family of products, thereby reducing the costs and time of developing and retooling for new product lines (Shirley, 1990, 1992; Suzue and Kohdate, 1988). Ford's new generation of engines, for example, is based on modular designs that have about 75 percent of their components in common across a broad range of engine sizes (Judge, 1991). Likewise, Honda's upmarket Domani sedan (currently for the Japanese market only) shares 60 percent of its components (by value) with the mid-market Civic model (Schreffler, 1993). Black & Decker Corporation has adopted modular product designs that share common modular components like electric motors across families of power tools (Lehnerd, 1987; DiCamillo, 1988). After buying out Philips' European home appliance business in 1989, Whirlpool launched a major product redesign program 'to ensure that a wide variety of models can be built on the same basic platform' with as many standardized parts as possible in each family of products (Maruca, 1994: 136).

Modular product design can also be used to increase the *modification flexibility* of product creation resources by creating a 'platform design' (Wheelwright and Sasser, 1989) for leveraging of technologically upgraded product models. In this case, the standardized interfaces between modular components are specified to allow for substitution of upgraded components as anticipated technological improvements in those components become available. Sony used the modification flexibility of its modular product design for the HandyCam video camera to leverage five upgraded models (based on technologically improved components) in the 23 months following its introduction (Sanchez, 1991, 1994a).

The modification flexibility to upgrade products is also increased when components can be reused from one product generation to the next, thereby lowering the costs and time for developing components and retooling for each new product generation. Hewlett-Packard, for example, wrestled a dominant position in the inkjet printer market from Japanese producers by rapidly introducing incrementally improved printers created by upgrading key components—but reusing the majority of components—within existing platform designs. Hewlett-Packard can thereby leverage a broad family of products 'consisting of slight variations of the same basic printer' (Yoder, 1994: A6).

A further flexibility of modular product design results when key components that bring perceived variety to a product (in the eyes of targeted customers) can be added late in the production or distribution process. In this delayed differentiation (Zangwill, 1993), components that do not add perceived variety are consolidated into a subassembly that is used in common across a product family, while components that do confer variety are grouped into subassemblies that can be added late in the final assembly process, at distribution centers, or even by customers. For example, Hewlett-Packard ships subassemblies of common components for its inkjet printers to local distribution centers around the world, where the power supplies and manuals required for each local market are added. This flexibility of modular product design allows Hewlett-Packard to 'carry as little inventory as possible, but . . . supply [many required variations of] products to end-users quickly' (Lee, Billington, and Carter, 1993: 2).

Marketing and distribution resource flexibilities

The flexibility of marketing and distribution resources to market a diverse line of products (i.e., their mix and modification flexibility) begins with the ability of a firm to segment markets—i.e., to identify groups of customers that share distinct preferences for a particular variation of a product (Kotler, 1991). In addition, the ability of a firm to identify useful upgrades and repositionings in product lines (its changeover flexibility) depends on its ability to discover changes in customer preferences. To be effective, a firm's marketing resource flexibilities must have corresponding distribution flexibilities to deliver product variations to targeted market segments in a timely manner (Shapiro, 1984).

Some firms have begun to use new flexibilities of development and production resources to engage in nontraditional marketing. To discover market segments and track market trends, they market 'learning models', which are product variations produced in small lots on flexible production systems. Such firms appear to have achieved sufficiently low costs and high speed in developing and producing new product variations that they can use 'real-time market research' (Sanchez and Sudharshan, 1992) to investigate the reactions of targeted customers to real products.

Point-of-purchase (POP) information systems make it possible to gather real-time sales data on new products, allowing timely and finely focused insights into current customer preferences. When current market information is used to direct the efforts of flexible development, production, and distribution resources, the marketing flexibility of a firm to discover and serve market preferences can be greatly increased. Retailers like WalMart and L.L. Bean, for example, have become leading users of integrated sales and logistics systems (often linked directly to key suppliers' production systems) to insure that their product offerings are those currently in greatest demand in each market they serve (Mitchell, 1991; Little, 1994).

Technology resource flexibilities

A technology has characteristics—often rather well understood within technical communities (Wade 1995)—that govern both the range of products to which the technology can be applied and the extent to which advances in the technology can support the upgrading of products. A technology that has a broad range of potential product applications (Hamilton, 1985; Mitchell and Hamilton, 1988; Prahalad and Hamel, 1990; Kim and Kogut, 1994) has mix and changeover flexibilities that allow development of product variations based on the technology. Similarly, a technology with significant trajectories of expected performance improvements (Stalk and Hout, 1990; Hilbrink, 1990, 1991; Sanderson, 1991) has modification flexibility that can support a succession of upgraded product models.

As Figure 2 suggests, the flexibility of a firm's overall product creation capability is dependent on the flexibilities in the *entire* chain of the firm's product creation resources. Product technology's most immediate interdependency is with a firm's product development resources. The ability of the firm to derive benefits from a flexible product technology will depend on the flexibility of the firm's development resources, especially the flexibility of its product design capability. Because modular product designs allow rapid and low-cost leveraging of product variations and upgraded models, modular product design offers a synergistic linkage between flexible product technologies and flexible production systems. The examples presented in this discussion suggest that when some firms develop flexible product design and production resources in an industry based on flexible product technologies, the ingredients for a major escalation of product-based competition come into place.

MANAGERIAL INNOVATIONS IN COORDINATION FLEXIBILITIES

Chandler's studies (1962) suggest how technological developments in railroads, telegraph, and accounting systems in the late 1800s led to managerial innovation of the multidivisional corporation as a new organizational structure for making effective use of the new technologies to coordinate large-scale production systems serving expanding market areas. Current technological developments are leading to a new wave of managerial innovation seeking to exploit the strategic potential of new technologies through innovative product strategies and organizational structures. Innovative uses of these technologies often require new methods for coordinating firm processes (Malone and Crowston, 1994).

This section examines four managerial innovations in the use of new information technologies and modular product design. This section also identifies ways in which these managerial innovations significantly improve a firm's *coordination flexibility*.

Managerial innovations in the use of new technologies

This section examines four managerial innovations in the use of new information technologies and modular product design: (1) the use of modular product design to facilitate the 'modular' organization of development and production processes; (2) the use of CADD/CIM/EDI technology as 'quick-connect' electronic interfaces between firms; (3) the use of both modular design and information technologies to support concurrent product creation processes; and (4) the use of information technologies for real-time acquisition of market information.

Modular organization of development and production processes

Implicit in any product design is a set of tasks that must be performed to develop and produce the components that make up a new product. When the interactions between components in a product design are complex and not well specified, the processes of developing and assembling those components require intensive interactions between the developers of interrelated components to insure that the components work together satisfactorily. Intensive component developer interactions usually require extensive involvement by the product-developing firm's managers to adjudicate technical, procedural, and sometimes financial concerns posed by component developers as they interact.

Overt managerial coordination of such processes requires an organizational structure with a clear and operative *authority hierarchy*. Thus, implicit in a product design with complex and incompletely specified component interfaces is a need for intensive coordination of development tasks, for the exercise of managerial authority, and for an organizational structure through which managerial authority can readily be exercised. Achieving these conditions may require that product creation processes take place within the hierarchy of a single vertically-integrated firm (Williamson, 1975, 1985, 1991) or within the hierarchy of a firm and a quasi-integrated group of dependent component suppliers (Nishiguchi, 1994).

In contrast, when a firm creates modular product designs that have well-specified, standardized interfaces between components that define the intended inputs and outputs of all components, the need for component developers to interact with each other or with the coordinating firm while performing their respective development tasks is greatly reduced. As a result, there may be little or no need for the exercise of overt managerial authority over developer processes, and hence little or no need for an organizational structure incorporating an authority hierarchy. Following this logic, Sanchez and Mahoney (1994) argue that the coordination tasks implicit in specific product designs largely determine the feasible organization structures for developing and producing those products. They suggest that, to a significant extent, *product designs constrain feasible choices of organization designs*.

As suggested in Figure 3, product designs with highly interdependent components that are 'tightly coupled' functionally require tightly coupled organization structures (Weick, 1976) for carrying out component development processes that will also be highly interdependent. Product designs that use standardized interfaces between components to create well-decomposed systems (Simon, 1962) of functionally separated, 'loosely coupled' components, however, enable component development processes to be carried out by loosely coupled (Weick, 1976) organization structures. Modular product designs that allow for a range of variations in loosely coupled, modular components can be carried out concurrently by multiple, loosely coupled, 'modular' organization structures.

Accordingly, managers of some firms have made strategic use of modular product designs to shift much of the overall product development task from processes requiring overt exercise of managerial authority to processes which can be managed through the specifications of standardized component interfaces in a modular product design. In this manner, standardized component interfaces can be used to achieve *embedded coordination*—i.e., they achieve coordination by means other than the overt exercise of managerial authority.

Achieving embedded coordination through modular product designs requires that a firm specify standardized interfaces for modular components such that (1) component specifications are readily understood by component developers, (2) component development proc-

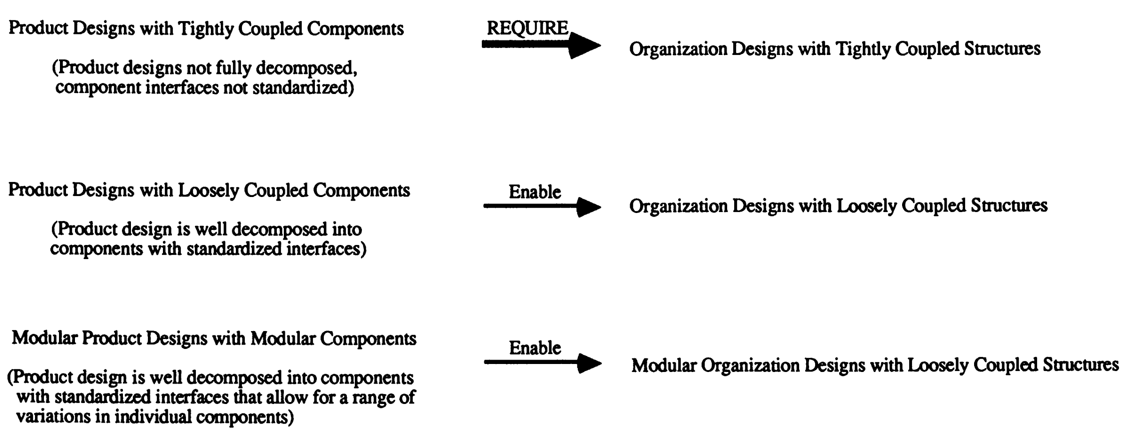

Figure 3. How produce designs constrain feasible organization designs.

esses can be carried out autonomously by component developers, and (3) each component developer's performance can be monitored by checking the conformance of each component to its interface specifications (Sanchez and Mahoney, 1994). When a modular product design meets these conditions, modular product design facilitates the adoption of a 'modular' organization design for product creation processes. In this sense, *a modular organization structure is one in which each participating resource can function autonomously and concurrently*, guided by embedded coordination. In Cummins Engine Co.'s product creation processes, for example, Cummins uses its control of the specifications of component interfaces within each new engine design to coordinate the development activities of a network of component developers and suppliers (Venkatesan, 1992).

Compared to managing development processes by the overt exercise of managerial authority, developing modular products through modular organization structures can substantially reduce the management task for each product creation project a firm undertakes. When used effectively, therefore, a modular product design strategy allows a firm to coordinate a potentially large network of product development resources using only limited management resources.

'Quick-connect' electronic interfaces

The potential increases in the flexibilities of product creation resources resulting from the reduced cost and increased speed of CADD/CIM systems are of considerable strategic importance. However, CADD/CIM systems' ability to *coordinate* product development and production processes may be of greater importance (Malone, Yates, and Benjamin, 1987; Malone and Rockart, 1991; Malone and Crowston, 1994; Sanchez and Mahoney, 1994).

A CADD/CIM system used in common among a network of firms provides standardized language, procedural protocols, design documentation, and shared data files that produce embedded coordination of development processes and reduce the need for overt managerial coordination of processes. Analogous to the effects of standardized interfaces between modular components, a shared CADD/CIM system provides standardized electronic interfaces between firms that facilitate the 'mixing and matching' of component developers and other resource providers in configuring product creation resource chains. A shared CADD/CIM system can thereby provide a *quick-connect electronic interface* (Sanchez, 1995) through which firms can quickly establish communication and coordination links.

A firm that uses quick-connect electronic interfaces to coordinate product creation resource chains may be able to link through its CADD/CIM system to a network of product creation resources and achieve superior speed and greater component variety in responding to new product opportunities. For example, Rubbermaid Corporation uses a CADD/CIM system for creating its plastic products which it is extending to an expanding network of suppliers of development resources (see Figure 4). By using this CADD/CIM-coordinated network to accelerate its product creation processes, Rubbermaid has reduced the time to bring a new product idea into production from over 30 weeks to about 12 weeks (in early 1994), with a goal of 6 weeks by the end of 1994. The objective of Rubbermaid's product strategy in 1995 is to use its network of product creation resources to introduce new household, office, and industrial products *at the rate of one per day*.

Concurrent product creation processes

Using modular product designs and CADD/CIM systems make possible *concurrent product creation processes* that greatly reduce the total time required to develop and manufacture a new product. The recent adoption of modular product design methodology by some automakers has helped those firms achieve concurrent product creation processes and significantly shorten product development cycles. After converting to an aggressive modular product design strategy and adopting CADD/CIM systems for its cross-functional concurrent development teams. Chrysler reduced its product development cycle from over 60 months to 36 months or less.[3]

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[3] As Chrysler sought ways to radically reduce its product development cycle times in the late 1980s, *The Economist* (29 July, 1989: 53) quoted Chrysler chairman Lee Iacocca as declaring, 'We gotta do cars differently. We gotta do modular stuff',

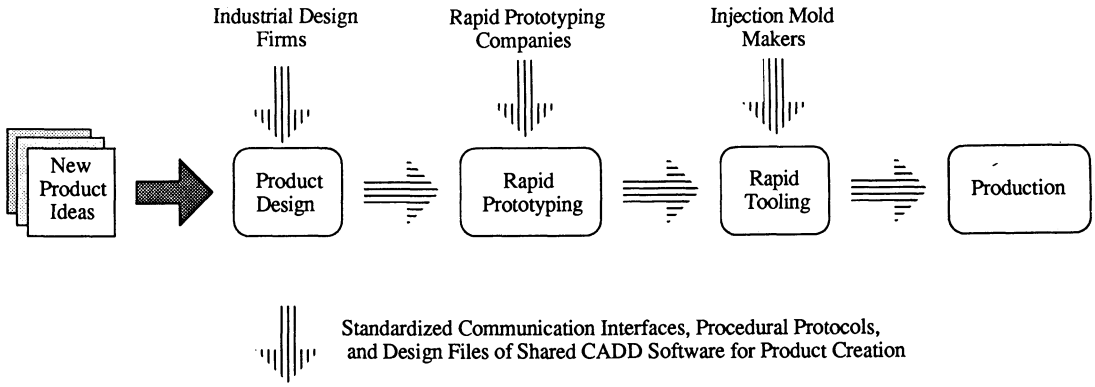

Figure 4. Rubbermaid's CADD-linked network of product creation resources.

Real-time acquisition of market knowledge

The traditional approach to acquiring market knowledge is to use traditional marketing research methods like consumer surveys or focus groups. (For a survey of marketing research methods, see Wind, 1990). Sanchez and Sudharshan (1992) have argued, however, that traditional marketing research methods may require too much time and produce findings that are too ambiguous to be useful in evaluating new product ideas in dynamic product markets.

To gather more timely and less ambiguous market information, managers in some firms make extensive use of new point-of-purchase (POP) technologies to gather up-to-the-moment sales data that are interpreted in real time by sales analysis computer programs to discover patterns and trends in current market preferences (Mitchell, 1991). When systems like these for generating up-to-the-moment information about market preferences are coupled with flexible product creation systems based on modular product design and CADD/CIM/EDI technology, a firm may be able to accelerate and refine its knowledge of market preferences and trends through real-time market research (Sanchez and Sudharshan, 1992).

Effects of managerial innovations on coordination flexibility

The foregoing managerial innovations in the use of new product creation technologies may significantly increase a firm's *coordination flexibility* by improving its ability to redefine its product strategies, to reconfigure new chains of product creation resources, and to redeploy chains of resources in support of redefined product strategies.

Increased flexibility to redefine product strategies

Manager's willingness and ability to redefine a firm's product strategies are likely to vary inversely with the perceived risk (Baird and Thomas, 1985; Hitt and Tyler, 1991) and difficulty of making the technological shift (Henderson and Clark, 1990) associated with a potential change in product strategy. Managerial innovations in using new information technologies to acquire more current and accurate market information can reduce the perceived risk of changes in product strategies, and managerial innovation in achieving the modular organization of product creation processes helps to reduce the difficulty of making the technological changes often required to change product strategies.

Flexibility from reduction of perceived risk. There is evidence that perceived uncertainty about the value of a new product idea in dynamic product markets can be reduced when managers can obtain current information about how a market is responding to *related products* (Eisenhardt, 1990). Managers that acquire fine-grained market knowledge about current related products through effective use of new information technologies may resolve market uncertainties quickly and accurately. As market uncertainties associated with a potential change in product strategy are reduced, the perceived risk of that strategic change diminishes. Although a firm can never gather adequate information to remove all uncertainties about a new product strategy, it may be able to gather enough market information to reduce perceived uncertainty and risk below the threshold which the firm's managers can tolerate when committing resources to new products.

More fundamentally, however, the actual risk of allocating resources to a new strategic use decreases with increasing flexibility of a firm's resources—i.e., with ability of the firm to switch resources to another use quickly and at low cost (Pindyck, 1991; Dixit and Pindyck, 1994). If managers correctly perceive the reduced risk inherent in committing *flexible* resources to an uncertain product opportunity, the level of product market uncertainty which managers can tolerate when committing resources to a new product idea should increase. Thus, the reduction in risks that results from use of flexible product creation resources may induce managers to introduce more innovative products, as well as larger numbers of product variations.

Flexibility from reduced difficulty of making a technological shift. Henderson and Clark (1990) suggest that product-creating firms are likely to adopt organizational structures that foster a narrow focus on incremental changes in components within a given product architecture. They argue that firms that progressively advance their technical capabilities in components tend to develop increasingly narrow cognitive limits that make it difficult to detect and respond to periodic radical innovations in components that lead to changes in product architectures. Managers in a firm using modular product design and a modular organization structure for product creation, however, are less likely to develop such cognitive limitations. This firm should be more capable of detecting and responding to opportunities for significant changes in products by making either incremental changes in components or radical component changes leading to new product architectures.

Radical technological changes leading to new product architectures occur relatively infrequently. Thus, most modifications and improvements in products are realized through changes in components that remain compatible with an existing product architecture. (Abernathy and Clark, 1985). Using real-time market information to discover promising new variations in component-based features of modular products can help a firm to redefine its product strategies at the component level. By using quick-connect interfirm linkages and concurrent product creation processes to coordinate suppliers, a firm may achieve significant flexibilities to offer a broad and frequently improved range of products based on component variations and upgrades. Indeed, component-based product variations drive much of the product competition based on rapid product proliferation, intensive market segmentation, and rapid performance improvement described earlier (Sanderson and Uzumeri, 1990; Sanderson, 1991; Sanchez, 1991, 1994a).

Moreover, a firm that uses modular product design and a modular product development organization is explicitly using the specifications of component interfaces that define a product architecture to manage product creation processes. Such a firm is not likely to be excessively focused on specific component development activities and thus would be unlikely to suffer from a limited ability to recognize and respond to radical changes in component technologies. This firm should be able to respond to infrequent radical innovations in components that lead to new product architectures by creating new standardized specifications for component interfaces that can accommodate radically new modular components (Morris and Ferguson, 1993; Venkatesan, 1992).

In addition, because modular product design permits a range of variations in the modular components that constitute a product (Sanchez, 1994a), significant technological change in a given modular component can often be accommodated with little or no modification required of other components. Thus, because modular product designs often limit or 'contain' the impact of changes in individual components on an overall product design (Simon, 1962), they may accommodate radical changes in components more readily than nonmodular designs.

Sony, for example, has responded to radical changes in component technologies by successfully making a transition from the analog cassette Walkman product architecture to the digital compact disc Discman product architecture. In making this transition, Sony used its modular design capabilities to define a new product architecture for Discman products that incorporated radically new digital technology components. The impact of those radically new components, moreover, was sufficiently contained by Sony's modular product design to allow carry-over of some basic components from the analog technology Walkman product architecture to the digital technology Discman product architecture (Sanderson, 1991).

Increased flexibility to reconfigure product creation resource chains

The resources available to a firm include its *internalized resources* (those it owns or controls directly), its *relational resources* ('nontradeable assets' (Dierickx and Cool, 1989) owned or controlled by other firms which the firm can access), and *market resources* which the firm can obtain the use of through market transactions. The greater the range of capabilities of a firm's internalized resources *and* the relational and market resources it can access, the greater its potential flexibiity to reconfigure product creation resource chains in response to changing market opportunities and threats. The number and diversity of product creation resources a firm can access increase with its ability to use modular product design and quick-connect electronic interfaces to coordinate an extended modular organization of development and production resources.

Increased flexibility to deploy product creation resources

Modular component specifications and quick-connect electronic interfaces allow *concurrent development* of components within a modular organization structure, greatly increasing the speed with which a firm can respond to product market opportunities or threats. Superior flexibility to quickly deploy product creation resources has become central to the product strategies of some notably successful firms in dynamic product markets (Stalk and Hout, 1990).

Nike, for example, developed a rapidly deployable resource chain for competing in the specialty shoe market. Currently, it acquires technologies through joint development ventures with companies holding relevant technology resources and uses its own internalized resources to design athletic and special-purpose shoes based on those technologies. It uses componentized shoe designs to coordinate the production resources of a network of manufacturing firms, but uses its own resources to market its products (Korzeniewicz, 1994). Similarly, IKEA assembled a product creation resource chain in which IKEA internally designs, tests, and retails its componentized furniture products, but uses a computerized production management system to coordinate manufacture of components by a global network of 1800 suppliers (Normann and Ramirez, 1993). The flexibility of firms like Nike and IKEA to rapidly deploy a broad base of product creation resources enables a quick response to diverse and rapidly changing market preferences.

A NEW DOMINANT LOGIC FOR DYNAMIC PRODUCT MARKETS

This section proposes that achieving resource and coordination flexibilities transforms the alternatives for competing in a given product market. Within this set of competitive alternatives, new patterns of resource use, deployed through new product strategies and organization forms, produce a *new dominant logic* (Prahalad and Bettis, 1986) for competing in dynamic, technologically transformed product markets.

The new dominant logic driving the search for competitive advantage in dynamic product market consists of several interrelated elements of strategic flexibility (Sanchez, 1993):

- real-time mediation of technology and market opportunities;
- dynamic efficiency in deploying resources;
- diversification through competence leveraging;
- flexibility in strategic decision making;
- achievement of dynamic equilibrium in a turbulent environment.

Each of these elements of strategic flexibility represents, in essence, an effort to exploit sources of competitive advantage in ways that have only recntly become technologically feasible.

Real-time mediation of technology and market opportunities

Increased flexibilities of resources and coordination capabilities increase the speed and precision with which firms can explore and exploit evolving opportunities at the interfaces of changing technologies and market preferences.

As a complement or alternative to relying on traditional marketing research, the new competitive logic seeks to achieve increased speed and greater precision in gathering market information to support intensive, continuous learning about markets (Day, 1994) in real time. In effect, the new competitive logic takes advantage of newly available means for top managers to recognize technology and market opportunities important in successful corporate entrepreneurship (Burgelman, 1983). Similarly, as a complement or alternative to making resource commitments to serving specific market preferences, the new logic creates and uses flexible product creation resources and coordination capabilities to offer an array of products to markets in real time (i.e., with the fastest possible response to changes in either market preferences or the technological means for serving those preferences).

The logic of real-time mediation of technology and market opportunities is a departure from a logic of committing to specific-use resources like constrained-optimized product designs and production systems dedicated to providing a narrow product line. In competition to discover and deliver the mix of price, quality, and features that markets value (Rose, 1991), the strategic flexibility logic achieves a fundamental shift 'from a *plan* to produce specific offerings for specific markets to a *structure* for sensing and responding to change faster than the competition' (Haeckel and Nolan, 1993: 131, emphasis in original text).

Dynamic efficiency in deploying resources

To compete in dynamic product markets, a firm must have substantial adaptive capability (Astley and Brahm, 1989). The logic of strategic flexibility seeks increased adaptive capability through improved dynamic efficiency in responding to product opportunities across multiple product market segments (Achrol, 1991).

Increased resource and coordination flexibilities reduce the cost, time, and difficulty of changing the mix and use of resources deployed by a firm in product competition. Achieving flexibility that reduces the cost and difficulty of changing and coordinating its resource base may make it attractive for a firm to compete on the basis of its dynamic efficiency in redeploying resources to take advantage of changing technology and market opportunities. Firms with superior dynamic efficiencies in reconfiguring and redeploying resource chains can adjust strategic assets faster than less flexible competitors.

Dynamic efficiency also benefits from a shift in the logic for coordinating processes from relying on the overt exercise of managerial authority to finding effective means to embed coordination. When a firm knows how to embed coordination to achieve the tight coupling of product creation processes through loosely coupled organizational structures, the firm increases its ability to access and use relational and market resources effectively. When a firm can access and use a variety of resources without incurring the full costs and risks of resource ownership, its fixed costs of maintaining a flexible response capability are reduced (Sanchez, 1993: 262–263), further improving its overall dynamic efficiency.

Diversification through competence leveraging

Managerial success in embedding coordination of product creation processes in modular product designs and CADD/CIM/EDI systems has suggested a new logic for organizing product creation processes that complements the emphasis on the strategic value of internalized firm resources in product competition (Wernerfelt, 1984; Dierickx and Cool, 1989; Barney, 1991; Grant, 1991; Peteraf, 1993). The new logic recognizes the strategic value of improved flexibility to respond to diverse and changing product opportunities by configuring and deploying a chain of product creation resources drawn from many firms. Recognizing the value of strategic flexibility motivates a shift in the logic of organizing product creation from relying on a vertically integrated organizational structure to achieve control of strategic resources to using modular product design and information tehnologies to achieve embedded coordination of networks of relational and market resources. In essence, the new logic uses new technologies to achieve *de facto* integration of product creation processes without using a (legally) integrated organization structure.

Using networks of product creation resources provides a means for the firm to leverage its flexible internalized resources by combining them with relational or market resources (Koenig and Thiétart, 1990; Sanchez, 1993). In particular, expanding 'the capability of the firm to exploit its knowledge and the unexplored potential of the [firm's] technology' through networks of resources increases a firm's 'combinative capabilities' (Kogut and Zander, 1992: 391–392). As Figure 2 suggests, important leverageable competences in dynamic product markets include product technologies, modular design capabilities, flexible production and distribution capabilities, superior market knowledge, and even project coordinating capabilities.

The ability to leverage competences through resource networks gives a firm new strategic options to *diversify* into more product markets or to *intensify* its presence in its current product markets. When a firm has leverageable competences that are upstream in the product creation resource chain shown in Figure 2 (e.g., flexible product technologies or flexible product development capabilities), the firm may be able to 'diversify' (indirectly) into a number of final product markets it could not otherwise reach by combining with the resources of downstream firms that are involved directly in various product markets. Similarly, a firm with flexible capabilities downstream in a product creation resource chain may be able to 'intensify' its presence in a given product market by combining with the flexible resources of upstream firms to leverage a broader range of differentiated products for more market segments or to upgrade product performance more rapidly.

Diversifying or intensifying by leveraging competence requires managerial abilities in 'identifying and developing those distinctive competencies that the firm can leverage into greater, more valuable sets of strategic options' (Sanchez, 1993: 281). Deciding which competences to develop internally and which to access through relational or market transactions (Sakai, 1990; Bettis, Bradley, and Hamel, 1992; Zachary, 1992) requires managerial insights into reallocating resources from activities that do not add value to those that do. Competences deserving careful evaluation for internalizing include capabilities for generating real-time market information (Gereffi, 1994), capabilities for defining and designing flexible product designs (Sanchez, 1994a), and product technologies capable of supporting significant product variety and rapid performance improvements (Bartmess and Cerny, 1993; Kim and Kogut, 1994). These competence areas are repositories of strategically useful 'sticky information' (von Hippel, 1994a, 1994b) about product technologies or markets which may serve to attract the interest and cooperation of component suppliers, manufacturers, distributors, or other relational or market resources.

These competences can be leveraged to help coordinate and manage businesses operating in different product markets (Hitt and Ireland, 1986; Hoskisson and Hitt, 1994). Thus, they help create and more effectively manage diversification. Nevertheless, firms with leaverageable capabilities must be mindful of potential dysfunctionalities which can result from overdiversification (Hoskisson and Hitt, 1994).

Flexibility in strategic decision making

Dynamic product markets in which competitors aggressively pursue new product opportunities create a highly complex and uncertain environment for deciding product strategies. Strategic decision making in such environments is likely to be influenced not only by rational analysis (Eisenhardt and Zbaracki, 1992), but also by perceptual and cognitive characteristics of managers that may vary by education, experience, organizational position, and individual personality traits (Hitt and Tyler, 1991). When managers make decisions in a rational manner, the inability to comprehend all the complex interrelationships in a firm's competitive environment may lead to 'boundedly rational' decision making (Simon, 1945) and to problemistic search (Cyert and March, 1963) for solutions among a limited set of perceived alternatives.

Nevertheless, studies of strategic decision making by managers of firms facing significant environmental uncertainty suggest that managers who try to avoid uncertainty in making resource allocation decisions compromise the economic performance of their firms (Bourgeois, 1985). Having strategic flexibility, however, makes it feasible for managers to maintain the 'multiple, simultaneous alternatives' characteristic of effective decision making in dynamic environments (Eisenhardt, 1990). Managers facing environmental uncertainty make better strategic decisions when they maintain multiple approaches (Quinn, 1986), because future events which cannot be perfectly predicted in dynamic markets may eventually reveal one approach to be preferable to others. Creating strategic flexibility enables a firm to 'position itself to take advantage of a greater number of fortunate future outcomes' (Sanchez, 1993: 286) in a dynamic environment.

In contrast to the strategic planning or 'intended' model (Ansoff, 1988, 1991) of strategic decision making, Mintzberg (1990, 1991, 1994) proposed that a less structured, more organic process of decision making enables good strategic decisions to 'emerge' from organizations. Sanchez and Mahoney (1994) argued that strategic flexibility offers a means of 'achieving an intended (planned) strategy of providing a range of flexible (emergent) responses to an uncertain environment', thereby allowing a 'fusion of intended and emergent strategies' (1994: 29–30). The ability of managers to create more flexible resources and more flexible coordination capabilities thus makes possible a new logic for strategic decision making in which managers can plan flexible responses to a range of possible future events in dynamic environments.

Achievement of dynamic equilibrium in a turbulent environment

Dynamic product environments can be destabilizing to firms that have difficulties in redefining product strategies and restructuring to implement new or modified product strategies. Strategic flexibility, in essence, creates and deploys flexible organizational processes that increase the firm's capability to generate the variety of responses required to maintain stability in a dynamic environment (Ashby, 1956; Ansoff, 1987). When a strategically flexible firm can routinely respond to a broad range of contingencies (Miller, 1987; Pennings, 1992; Schoemaker, 1993) encountered in a turbulent competitive environment without being destabilized by frequent organizational restructurings, it may achieve a state of dynamic equilibrium in the midst of constant organizational change.

Creating and deploying strategic flexibility is a higher-order strategic process (Sanchez, 1994b) that allows continuity of strategic intent (Hamel and Prahalad, 1989) even when a firm's product strategies in various markets undergo frequent change. Strategic flexibility is therefore a logic for maintaining a dynamic equilibrium while managing technological and market change in a turbulent environment.

CONCLUSIONS

Technological innovations in modular product design and CADD/CIM systems have greatly increased the flexibilities of product creation resources. These technological innovations have inspired managerial innovations in coordinating flexible resources through new product strategies and organizational structures, and the confluence of these technological and managerial innovations has produced a new dominant logic of strategic flexibility for competing in product markets. Below are some questions about the nature of flexible strategies and organizations in transformed competitive environments, and some brief answers intended to stimulate further thinking.

1. *What are the sources of 'sustainable competitive advantage' in dynamic product markets?* No specific resource is likely to result in sustainable competitive advantage, because the value of resources as strategic assets erodes over time (Dierickx and Cool, 1989). Specific-use capabilities and resources may lead to temporary competitive advantages. Much competitive advantage in dynamic markets, however, results from a superior ability to continuously replenish a product creation resource chain with strategically useful internal, relational, and market resources, and from a superior ability to configure varied resources to take advantage of dynamic product opportunities. Firms have differential abilities in creating and exercising strategic flexibilities. Thus, in a dynamic product market, relative competitive advantage may be explained largely by firms' differing strategic flexibilities to discover and exploit new market opportunities and to outmaneuver competitive threats in product markets.[4]

[4] This perception of the source of competitive advantage suggests the need for new kinds of independent variables in predicting firm performance in dynamic markets. These variables will have less to do with resources that are easy to identify and measure (like fixed assets) and more to do with capabilities (including capabilities to make effective use of relational and market resources) that are difficult to identify and imitate—and *for that reason* may be difficult to define precisely and parameterize.

2. *Is the strategically flexible firm a fundamentally new type of organization?* Firms may be classified in a number of ways, including the way they interpret their environment. As an interpretation system (Daft and Weick, 1984), the strategically flexible firm is effective in promoting organizational learning about its environment. On the one hand, it may use its flexibilities to *scan* its environment (markets and technologies outside the firm) quickly and in considerable detail. On the other hand, by achieving a dynamic equilibrium that serves as an effective framework for managers to develop shared understandings of resource and coordination flexibilities that are strategically useful in a rapidly changing environment, it may be able to *initiate* a range of actions to determine the 'action outcome relationships' that constitute organizational knowledge of an environment (Daft and Weick, 1984: 286). The interpretation mode of the strategically flexible firm is therefore likely to be a hybrid of 'discovering' and 'enacting' its environment (Daft and Weick, 1984). Strategically flexible firms interpret by enacting at the market segment level through real-time mediation of technology and market opportunities, but interpret by discovering when they rely on managerial recognition of resource and coordination flexiblities that will be strategically useful in the future. From this perspective, strategically flexible firms represent a new hybrid interpretive organization.
3. *Does strategic flexibility represent a fundamentally new mode of strategic adaptation?* In viewing a firm as an open system that tries to maintain equilibrium through adaptation, Hrebiniak and Joyce (1985: 339–343) suggest that a firm may undertake adaptation by design, adaptation within constraints, adaptation by chance, or no adaptation at all. Adaptation by design occurs when a firm desiring to exercise strategic choices faces low constraints from (low levels of) environmental determinism, and adaptation within constraints results when a firm with a desire to exercise strategic choice faces constraints imposed by high environmental determinism. Organizations that can adapt by design may move freely among product markets or niches, while firms that must adapt within constraints are limited to pursuing focused differentiation strategies (1985: 339).

In the framework presented here, strategic flexibility varies inversely with constraints a firm faces on the products it can create and offer to markets. A firm enjoying a high degree of strategic flexibility (i.e., low constraints from low environmental determinism), however, may adapt to a changing environment by diversifying into a range of product markets *or* by intensifying its product offerings within a product market. A firm using its strategic flexibility to intensify its offerings in a product market at a given point in time may do so because its managers believe that is where the firm's best opportunities to create value currently lie, rather than because of high environmental determinism. The ability of a strategically flexible firm to engage in either mode of adaptive behavior in a dynamic market suggests that it may be essential to recognize the role that resource and coordination flexibilities play in making possible alternative modes of organizational adaptation. Gaining further insights into the roles of flexible resources and coordination flexibility in mediating between strategic choice and environmental constraints could benefit theoretical development of the strategic flexibility framework.

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