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Preparing for an Uncertain Future

Managing Organizations for Strategic Flexibility

In recent years, the rapid development of major new technologies, the increasing globalization of markets, the rise of innovative new forms of organizations, and the appearance of new patterns of intense competition have created unprecedented levels of environmental change and uncertainty for organizations of all types. As organizations try to prepare for futures with significant uncertainties, they are finding that many traditional management concepts that have helped to achieve organizational success in stable environments do not effectively prepare organizations for an increasingly dynamic and uncertain future. In the worst cases, following traditional management emphases on optimizing the efficiency of current processes may commit an organization to a narrow focus that severely limits its ability to respond to a changing environment. As an alternative approach to managing for an uncertain future, new management theory and practice have begun to focus on developing an organization's *strategic flexibility* to respond more readily to changing technological and market opportunities.

This paper draws together ideas from recent work on strategic flexibility to present the essential features of a new conceptualization of what strategic managers can do to help prepare organizations for a dynamic and uncertain future (Sanchez, 1991, 1993, 1994, 1995, 1996, 1997; Sanchez and Heene, 1996, 1997; Sanchez and Mahoney, 1994, 1996; Sanchez and Thomas 1996). We begin by defining *strategic*

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flexibility as the condition of having strategic *options* that are created through the combined effects of an organization's *coordination flexibility* in acquiring and using *flexible resources.*

The paper then characterizes the process of managing to prepare for an uncertain future as fundamentally an effort to identify and achieve the right "strategic balance" in building new organizational competences that create new strategic options and in leveraging current competences through the exercise of existing strategic options. Meeting this challenge requires that managers create a positive-gain "virtuous circle" of developing and using resource and coordination flexibilities that create the strategic options and resulting strategic flexibilities that are most useful in managing the future uncertainties facing an organization.

Competence building and leveraging are most effective in creating the strategic flexibilities needed to manage future uncertainties when an organization both uses planning approaches to strategic management and at the same time allows for locally emergent strategies and "spontaneity" in responding to a changing environment.

How an organization might achieve an effective fusion of planning and emergence in creating strategic flexibility is illustrated through a discussion of the strategic use of *modularity* in product, process, and knowledge architectures.

The concluding section explains how the strategic flexibility approach to preparing for the future differs from and extends previous strategic management frameworks.

Strategic flexibility from resource flexibility and coordination flexibility

The term *strategic flexibility* has recently come into wide use to denote an organization's various abilities to respond effectively to various aspects of a changing competitive environment. Research on these various concepts of strategic flexibility covers a broad territory from empirical investigations of the relative flexibilities of alliances and vertically integrated firms to manage demand volatilities (Harrigan, 1985) to conceptualizations of the degrees of freedom of managers in high technology product markets to coordinate "products, manufacturing processes, markets, distribution channels, and competitive boundaries [that] are in a state of continuous flux" (Evans 1991). What

clearly emerges from the diverse studies of strategic flexibility is the basic finding that the traditional strategic management objective of choosing a single "best" plan of action is likely to be an unrealistic objective in an uncertain environment. Rather, it often appears that firms generally improve their chances for being successful (and surviving) in an uncertain environment by creating strategic flexibilities that give them the ability to pursue alternative courses of action—or *strategic options*—in responding to changing environmental conditions (Sanchez, 1993, 1995).

The perspective on strategic flexibility developed here suggests that creating a range of strategic options requires that an organization have access to flexible resources and be able to be flexible in coordinating those resources in alternative uses. This view draws on the insights of Edith Penrose, whose notion of a firm as a "collection of productive resources" (1959, p. 24) is a cornerstone of the resource-based view of the firm in strategic management. In a conceptually important elaboration, however, Penrose also 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, p. 25, emphasis in original). Since the "services of resources" are obtained through the *use* of resources, a firm's strategic flexibility—that is, its set of strategic options—depends *jointly* on the *inherent flexibilities of the resources* available for use by the organization and on the *organization's flexibilities in applying those resources* to various uses in pursuing alternative courses of action. In managing for an uncertain future, strategic managers must therefore try (i) to identify and acquire the use of *flexible resources* that can be used in alternative courses of action, and (ii) to develop *flexibilities in coordinating* the use of resources in alternative courses of action.

Resource flexibility

The essential flexibilities of resources can be characterized by three dimensions of potential uses of resources:

1. Resource flexibility is greater when *there is a larger range of alternative uses* to which a resource can be applied. In essence, resource flexibility increases when a resource can be used to develop, manufacture, distribute, or market a range of different products.

2. Resource flexibility is greater when *the costs and difficulty of switching* from one use of a resource to an alternative use *are lower*. For example, the flexibility of a production line increases when the cost of switching from the production of one product to another decreases.
3. Resource flexibility is greater when *the time required to switch* to an alternative resource use *is lower*. The flexibility of a production system increases when the time required to switch from producing one product to another decreases. Implicit in this dimension of flexibility is that there is an opportunity cost incurred during the "down time" required to switch from one use to another.

These dimensions of resource flexibility are *inherent properties* of resources. In this regard, these essentially technical properties of resources represent the intrinsic limits to the number of uses a resource can be put to and the least possible cost, difficulty, and time of switching a given resource between alternative uses. How many alternative uses of a resource can be understood by a specific organization and the costs, difficulty, and time required for that organization to switch a resource from one use to another will, of course, also depend on that organization's understanding of the resource—a consideration that is elaborated below under the concept of "coordination flexibility."

The concept of resource flexibility, however, suggests that the overall flexibility of an organization will be limited by the inherent limitations or *inflexibilities* of the least flexible resource in the chain of complementary resources required by an organization to carry out some actions. In other words, the least flexible resource in a firm's resource chain acts as a "flexibility bottleneck" that limits the firm's strategic options for action—and thus its strategic flexibility. Interdependencies among various kinds of organizational resources have been noted by a number of researchers, including interdependencies between production flexibilities and product strategies (Gerwin, 1989; Wheelwright and Hayes, 1985), production and marketing flexibilities (Blois, 1985; Jaikumar, 1986), product development and production flexibilities (Clark, Chew, and Fujimoto, 1992; Hayes, Wheelwright, and Clark, 1990), and technological change, manufacturing flexibility, and product strategies (Sanderson and Uzumeri, 1997). What the resource flexibility concept described here adds to these observations is

the notion that the *systemic interdependence* among all the flexibilities in a firm's chain of resources constrains a firm's strategic flexibility. Further elaboration of systemic interactions in using complementary resources may be found in Sanchez and Heene (1996, 1997).

Coordination flexibility

The notion of organization connotes at least some process of coordination between the constituent parts of an organization. Andrews suggests that the essence of coordination is the "way in which subdivided functions and interests are resynthesized" (1980, p. 121), and Barnard argues that "the creative side of organization is coordination" (1938, p. 256) among the constituent parts of an organization.

Within the strategic flexibility perspective described here, coordination flexibility has three important dimensions:

1. *Defining the uses* to which an organization's resources will be applied. This ability includes, for example, deciding which products or services a firm will create, produce, and/or market.
2. *Configuring (identifying and structuring) chains of resources* capable of being applied in the uses targeted by an organization. This ability reflects the extent to which a firm can draw on a pool or network of resources and link those resources in a "value chain" of activities capable of creating, producing, and marketing products and services.
3. *Deploying resources* through organizational systems and processes that apply available resources to targeted uses. This ability reflects the extent to which an organization can effectively manage a chain of linked resources applied to a given purpose.

As with the dimensions of resource flexibility, each of these dimensions of coordination flexibility increases with an increase in the range of possibilities and a decrease in the cost, difficulty, and/or time required to realize a given possibility. The coordination flexibility to define new resource uses, for example, increases with the range of feasible resource uses that an organization can imagine and with any reductions in the cost, difficulty, and time required to define those resource uses. Similarly, the coordination flexibility to configure resource chains increases with the range of alternative resource chain configurations that an organization can determine are feasible for car-

rying out a given purpose, while that flexibility also increases with reduced cost, difficulty, and time required to determine alternative resource chain configurations. And the coordination flexibility to deploy resources increases with the range of alternative systems and processes an organization can identify as feasible for using resources to pursue a given purpose, and it increases with reduced costs, difficulty, and time required to determine an alternative system and process.

Moreover, just as the resource flexibility of the firm is limited by the inflexibility of the least flexible resource in the firm's chain of complementary resources, coordination flexibility is constrained by the least flexible capability of an organization to redefine new uses for available resources, to reconfigure chains of resources, and to redeploy resources through alternative systems and processes.

Creating strategic flexibility through competence building and leveraging

To prepare for an uncertain future, organizations must create new competences that give the firm strategic options for meeting the demands of the future; at the same time, to survive in the near term, organizations must be able to respond to current opportunities and threats by using existing competences to exercise their best existing strategic options (Sanchez, Heene, and Thomas, 1996; Heene and Sanchez, 1997). Managers seeking to assure the viability of their organizations in the long term must therefore engage in a continuous cycle of competence building by creating the right kind and range of resource and coordination flexibilities, coupled with competence leveraging that is effective in using the current resource and coordination flexibilities of the organization.

A useful way of conceptualizing this process is suggested in figure 1. An organization's current competences can be leveraged through exercising some of the organization's strategic options that are made possible by its current competences. Exercising some of an organization's current strategic options generates flows of financial resources (as well as learning, reputation, relationships, and other intangible resources), some of which may be reinvested in acquiring new resources and coordination capabilities that build new competences that create new strategic options for the organization. Some of the organization's new and preexisting competences may then be lever-

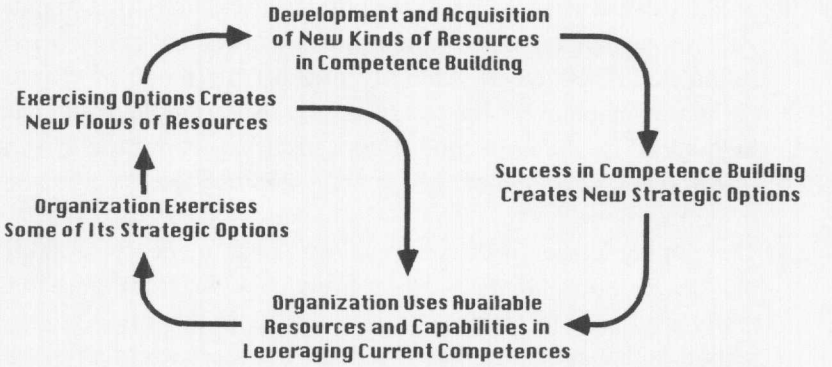

Figure 1 Creating a "Virtuous Circle" of Competence Building and Leveraging

aged by exercising some of its new and/or preexisting strategic options, which generates new flows of financial resources, some of which can be reinvested in creating new resources and capabilities that create new competences that bring new strategic options, and so on. Sanchez and Thomas (1996, p. 68) have suggested that "this 'virtuous circle' of competence building and leveraging in creating and exercising strategic options constitutes the quintessential dynamic" of managing organizations in a changing environment.

To manage this dynamic of competence building and leveraging effectively in preparing for an uncertain future, an organization must develop both the right kinds and the right "strategic balance" of resource flexibilities and coordination flexibilities, while making use of both internal and external sources of resources and capabilities (Sanchez and Heene, 1996). In analyzing the mix and balance to be sought in managing the stocks and flows (Dierickx and Cool, 1989) of resources and coordination capabilities in competence building and leveraging, it is useful to recognize that various forms of strategic flexibility may be created by three kinds of resource accumulations:

1. Building up stocks of "like-kind" resources. This is a process of acquiring greater quantities of resources that are qualitatively similar to those an organization already has and uses. Like-kind resources are resources an organization already knows how to use in its current patterns of activity.
2. Developing new kinds of "specialized-use" resources that are

qualitatively different from those currently available to an organization. Specialized-use resources are resources that are effective (often highly effective) primarily in a narrow range of uses or perhaps even in a very limited single use. An example would be a high-speed machine for producing a specific part or product or a research and development group with expertise in a specific area of technology.

3. Developing stocks of or access to new kinds of flexible "multiple-use" resources that are qualitatively different from those currently available to an organization. Multiple-use resources are resources that can be applied to a range of uses, such as a flexible manufacturing system or a group of product design engineers with capabilities that can be applied to a broad range of products.

Obtaining the strategic flexibilities potentially available from these kinds of resources may require different kinds of coordination flexibilities within an organization. In the final analysis, achieving an effective strategic balance will require reconciling available resource and coordination flexibilities with the most critical forms of uncertainty facing an organization.

The ability to build up or deplete stocks of *like-kind resources* increases the flexibility of an organization to respond to changes in the demand levels for the organization's current products or services. A resource build-up that creates slack organizational resources thereby creates a strategic option to expand output levels quickly if demand levels increase in the future, giving an organization a potentially important source of "output scale" flexibility. Carrying slack resources usually imposes costs, however, so the existence of ready markets for sourcing more like-kind resources may confer even greater flexibility by allowing supplies of inputs to either expand or contract in response to demand fluctuations (Sanchez, 1993). The output flexibility conferred by these forms of like-kind resource flexibility may often be realized without requiring changes in a firm's existing coordination flexibilities—that is, by using greater amounts of like-kind resources in leveraging current competences through existing products, resource chain configurations, systems, and processes.

Markets may also be sources of new kinds of *specialized-use resources* that are qualitatively different from those an organization currently has, and thus may provide resources that enable a firm to expand

the range of activities it may undertake. The availability of new kinds of specialized-use resources may therefore increase the potential "output scope" flexibility of an organization. Increasing the diversity of special-use resources available to an organization, however, will impose additional costs if those new resources are held as slack resources within the organization. Using markets or quasi-market arrangements like strategic alliances to source special-use resources when needed may remove the carrying cost of maintaining the availability of special-use resources (Sanchez, 1993) and thus may be a more efficient strategy for increasing output scope flexibility than internalization of slack specialized-use resources. Coordinating the use of qualitatively new kinds of resources, however, will generally require an expansion of the coordination flexibility of an organization, whether in deploying the new resources to new uses, in configuring new resource chains capable of incorporating the new resources, or in devising new systems and processes for deploying the new kinds of resources.

Having flexible *multiple-use resources* that are closely aligned with complementary coordination flexibilities may be an even more economically efficient strategy for managing the stocks of resources in an organization facing environmental uncertainty (Sanchez, 1995). The availability of new kinds of multiple-use resources may increase the potential "output scope" flexibility of an organization while avoiding the high fixed costs of internalizing a range of specialized-use resources, some of which are likely to be idle when the organization is pursuing objectives to which some specialized-use resources are not applicable (Sanchez, 1993). When an organization's existing stock of flexible resources can be coordinated and applied to the current best uses of those resources (within their range of possible uses), an organization's stock of flexible resources may remain fully employed and thereby avoid the costs incurred in carrying slack like-kind resources or redundant special-use resources.[1] In addition, since creating coordination flexibilities also incurs some initial or "sunk" costs, further cost efficiencies may be achieved when the range of coordination flexibilities of the organization are well matched with the flexibilities of the organization's current resources.

Achieving the best strategic balance between competence building and competence leveraging within an organization requires identifying the most advantageous combination of benefits (of strategic options created) and costs (of creating and exercising strategic options) prom-

ised by the alternative combinations of resource and coordination flexibilities that the organization is capable of imagining. Moreover, specific combinations of resource and coordination flexibilities may confer greatly different kinds and levels of strategic flexibilities and competitive advantages in different environmental contexts (Sanchez, 1996). In an environment where product concepts and production technologies are stable but demand levels may fluctuate widely over time, for example, the most advantageous strategic balance of resource and coordination flexibilities may be high levels of internalized slack like-kind resources, coupled with the limited coordination flexibility needed to manage those resources. On the other hand, in an environment where product concepts and available technologies are changing rapidly, the most advantageous strategic balance may be achieved by minimizing internalized resources while contracting widely for specialized-use resources available through markets or alliances, coupled with a high level of coordination flexibility to target, configure, and manage rapidly changing chains of market-sourced resources.

Thus, the strategic balance to be sought in competence building and leveraging is not a simple equilibration of internalized resource and coordination flexibilities, but rather is the most advantageous balance attainable among an organization's internalized resource and coordination flexibilities, the resource and coordination flexibilities that can be derived from sources outside the firm, and the input and output uncertainties that the organization must manage in the near term and long term.

Realizing strategic flexibility through planning and emergence

Sanchez and Mahoney (1994) have noted the longstanding debate in strategic management over the appropriate relative emphasis to be placed on planning versus emergence, an ongoing debate which they point out has a clear antecedent in debates in economics on the relative merits of centralized economic planning (Lange, 1936) versus decentralized coordination (Hayek, 1945). While Lange argued that systematic planning on a large scale was workable and may provide a superior approach to organizing economic activity, Hayek asserted that decentralized markets are more capable of interpreting rich and changing sets of information and therefore advocated economic organization through "human action without human design," resulting in an emerg-

ing "spontaneous order" (Hayek, 1978, p. 183). In the field of management, the issue has perhaps been joined most forcefully in the Ansoff-Mintzberg debates (Ansoff, 1988, 1991; Mintzberg, 1990, 1991) over the merits of strategic planning versus emergent strategies at the firm-level. Mintzberg's concept (1978) of emergent strategies is reminiscent of Hayek's (1978) "spontaneous ordering" in asserting that, in a complex and changing environment, coherent patterns of actions cannot be delineated *ex ante* by a human mind, but rather emerge as events unfold and are subsequently apprehended *ex post* by participants in the process.[2] Taking an institutional perspective that is "mid-range" between the macroeconomic view of Lange and Hayek and the firm-level view of Ansoff and Mintzberg, however, Williamson (1991) argues for interpreting the "institutions of capitalism" and the adaptation that occurs within that institutional framework as evidence of the feasibility and benefits of achieving a synthesis of planned and spontaneous ordering.

The strategic flexibility perspective described here proposes that realizing the full benefits of the strategic flexibilities an organization creates through its competence building and leveraging requires both using planning approaches to management and allowing for locally "emergent strategies" that enable some measure of organizational "spontaneity" in responding to a changing environment. The building of organizational competences requires *ex ante* processes for identifying and developing resource and coordination flexibilities that will give an organization basic strategic options to respond to some intended range of uncertain future outcomes. Simply put, creating basic strategic options and the strategic flexibilities they confer requires some form of planning. The set of basic strategic options created through planning processes, however, makes possible the evolutionary development of a derived set of specific strategic options in an organization. Thus, the planning process for creating basic strategic options both enables and constrains the emergence of near-term strategies of options developing and exercising in the organization's responses to environmental change. In essence, planning must direct basic competence building efforts, but emergence may guide more specific forms of competence building and competence leveraging. Realizing strategic flexibility jointly through longer-term planning for basic competence building and near-term, emergent forms of specific competence building and leveraging may achieve a synthesis of planning and emergence that

may constitute a new dominant logic for managing organizations facing significant future uncertainties (Sanchez, 1995).

Strategic flexibility in modular product, process, and knowledge architectures

Simon (1981) proposes that complex systems, whether physical systems or organizations, have hierarchical structures that may be decomposed into component parts. Elaborating on Simon's (1981) notion of hierarchies in complex systems, Williamson (1986, p. 146) proposes a principle of hierarchical decomposition for complex organizational structures in which there should be "quasi-independence between the parts, [with] the high-frequency dynamics (operating activities) and low-frequency dynamics (strategic planning) . . . clearly distinguished." Sanchez and Mahoney (1994) have suggested that this principle is reflected in the new dominant logic of developing organizational strategic flexibility as a basic approach to managing future uncertainties. They make an argument that parallels Williamson's analysis by noting that "the most viable organizational form may be a strategically flexible firm capable of exercising a range of emergent strategies (high-frequency dynamics) made possible by the planned creation of modular product and organization designs (low-frequency dynamics)."

This section summarizes arguments made in Sanchez and Mahoney (1994, 1996) and Sanchez (1991, 1993, 1995, 1996) that *modularity in product and process architectures* greatly facilitates the creation and realization of strategic flexibility by an organization. This discussion will suggest that the creation and use of modular product and organization architectures not only reflect Simon's and Williamson's insights into the possibilities for hierarchical decomposition of complex organizations, but demonstrate a management framework within which a synthesis of planning and emergence can be achieved in actual practice. The discussion also mentions the notion that modular product and process architectures create knowledge architectures that can enhance the management of organizational learning.

Modularity in product and process architectures

Most products—including services, software, and assembled goods—consist of several interrelated functions that combine together to pro-

vide the overall set of functionalities that distinguish one product from another. Thus, the process of designing a new product typically begins by decomposing the new product concept into a *system of functional components* whose individual functions collectively interact to provide the overall functionalities desired in the product. A *product architecture* for the new product concept is defined when (1) a new product design is decomposed into a system of functional components, and (2) the interfaces that determine how functional components will interact in the design are fully specified (Henderson and Clark, 1990; Sanchez, 1995; Sanchez and Mahoney, 1996). The component interface specifications in a product architecture define, for example, how one component may be physically connected to another (the attachment interface), how power is to be transferred between components (the transfer interface), how signals will be exchanged between components (control and communication interfaces), the spatial location and volume a component may occupy (spatial interfaces), and various ways in which the functioning of one component may generate heat, magnetic fields, or other environmental effects that must be accommodated by other components (environmental interfaces) (Sanchez, 1994).

The design of an organizational process has analogous properties of decomposability and interactions between component functions. Creating an organizational process design may therefore proceed in much the same manner—determination of the overall functionalities to be provided by the process, decomposition of the desired overall process functionalities into functional process components, and specification of how the various functional process components will interact in the overall process. In the case of organizational process designs, the specification of interactions between functional groups will include defining how one component may be physically located relative to another, how work-in-process is to be transferred between groups, what kind of information will be exchanged between groups, how that information will be transferred, and so on. The decomposition of a process into functional components and the specification of how those components will interact therefore creates a *process architecture* that is conceptually analogous to a product architecture.

There is more than one way, however, to approach the design of products and processes. Two fundamentally different approaches will be distinguished here as *conventional* and *modular* approaches to cre-

ating product and process architectures. The conventional approach to product and process design typically begins with some research or discussion process to define the specific product or process functionalities, performance levels, and maximum cost of a desired new product or process. Given this defined set of "optimal" product or process attributes, the objective of the design activity is to create a product or process design that provides the desired attributes at the lowest possible cost or the highest level of performance within a specified cost constraint. This conventional approach to creating a product or process architecture typically results in complex designs in which technically separable functions have been integrated into "tightly coupled" functions (Orton and Weick, 1990) to increase performance and/or to lower costs. An example of a product design created in this manner is a high-speed production system in which several functions may be performed by each machine and all machines are linked by specialized automated transfer mechanisms for rapidly moving specific kinds of work-in-progress between machines. A process design reflecting this approach might be an integrated process for receiving, processing, and settling insurance claims in a single location (even though the people in the single location may carry out the separate functions that require different skill sets).

In contrast to the conventional approach to creating product and process architectures, the modular approach intentionally tries to create a product or process design that permits the "substitution" of different versions of functional components (Garud and Kumaraswamy, 1993) for the purpose of creating product or process variations with different functionalities or performance levels. In effect, the objective of the modular approach is to create a flexible product or process architecture that can accommodate functional variations needed to serve a range of requirements. To create a flexible product or process architecture, modular design avoids creating strong interdependencies among specific component designs and instead seeks to create "loosely coupled" component designs in which any of several component design variations (within a specified range of variation) will routinely work in conjunction with any of several component design variations in another type of component (within its specified range of variation).

A familiar example of a modular architecture in a product is the personal computer, which generally allows ready substitution of various hard disk drives, memory cards, monitors, and the like, within its

product architecture. The ability to configure a product as a system by "mixing and matching" variations of functional components brings important forms of strategic flexibility (Sanchez, 1995, 1996) in managing product market uncertainties. Creating a modular product architecture increases the flexibility of a firm to offer a larger number of product variations simply by "mixing and matching" components within the product architecture. The flexibility to configure a range of product variations creates a range of product options that are readily available for responding to evolving market preferences. Modular product architectures may also be designed to accommodate improved components that are expected to become available in the future; the ability to introduce upgraded product models as soon as better components become available provides greater flexibility to respond to changing technologies and market expectations.

A comparable objective of the modular approach to the design of organizational processes is to create the ability to reconfigure the organization as a system readily by substituting functional process variations into the process architecture. Creating a modular organization design may also realize strategic flexibility benefits analogous to those achieved by modular product architectures.[3] The specification and *standardization*[4] of the input and output interfaces between processes in a modular process architecture create a stable *information structure* that provides a vehicle for *embedding coordination* of loosely coupled process functions. Within this stable information structure, the process function of one activity group is not affected by activities in another function group, as long as all functional groups conform to the input and output specifications for their activity in the modular process architecture.

The creation of modular process architectures can confer important forms of strategic flexibility:

1. Just as adoption of well-defined standard operating procedures may greatly reduce the management resources that must be allocated to managing a stable process, adoption of well-defined standardized input and output specifications in a modular process architecture can greatly reduce the need for direct inputs of management resources to manage change processes within the range of process variations allowed by the modular process architecture. In effect, as long as it stays within the defined range of

permissible input and output variations for its process, the group responsible for a given process function can become largely *self-managing and autonomous* (Sanchez, forthcoming). Reducing the management resources needed to accomplish adaptive change within the organization lowers the cost and difficulty of responding to changing environmental conditions, thereby contributing to the strategic flexibility of the organization. Chrysler Corporation's ability to use modular "platform" architectures for its cars to define (and thereby coordinate) the outputs of multiple teams developing new car components, for example, has largely eliminated the need for the traditional management function of coordinating activities across what have become loosely coupled component development groups. Using modular product and process architectures has contributed to Chrysler's ability to develop cars with greatly reduced management resources (Holmes, 1995).

2. Because a modular process architecture allows ready reconfiguration of organizational processes within the range of variations permitted by the modular process architecture, the *speed of organizational reconfiguration* in response to a changing environment can be increased, thereby enhancing the organization's strategic flexibility. In addition, because functions within a modular process architecture are loosely coupled, they also have the potential to be carried out concurrently. Chrysler's use of a modular product and process approach to coordinating development teams has enabled it to adopt largely concurrent processes for developing major body and mechanical components. As a result, the average time to develop a new car at Chrysler has declined sharply from an average of fifty-four months in 1987 (before conversion to the platform team development concept) to thirty-two months at the end of 1995, with a further goal of reducing development time to twenty-four months by the year 2000 (Holmes, 1995). Reducing the time required to respond to changing market conditions with new products, for example, is an important improvement in strategic flexibility when the opportunity costs of being slow to respond to changing market conditions are high.
3. Modular process architectures may also improve the ability of an organization or network of organizations to innovate within functional processes. Within the range of variations of inputs and outputs permitted by a modular process architecture, both routine

processes and efforts to innovate through experimental process variations can be carried out autonomously by individual functional groups. Thus, the loose coupling of processes within a modular process architecture brings increased freedom to innovate within functional processes. The loose coupling of functional processes may also enable greater involvement of customers and new suppliers in process improvements. Because changes within one process function that remain within the input and output specifications of a modular process architecture do not affect the process functions carried out by other groups, complicated intra- or interorganizational decision making is avoided, enabling customer or supplier suggestions for process improvements to be evaluated and acted on much more readily. Modular process architectures may therefore improve the strategic flexibility of a firm by improving its ability to gather and incorporate new market information and new technologies in continuous, concurrent process improvement.

4. Creating a modular process architecture also provides the means to coordinate a potentially widely distributed network of loosely coupled process functions. The fully specified process interfaces in a modular process architecture enable tasks to be allocated not only to groups within an organization, but also to the most capable or lowest-cost functional groups wherever those groups may be located. In effect, fully specifying process interfaces creates an "open architecture" for "quick-connecting" (Sanchez, 1996) a network of loosely coupled functional groups around the world, enabling an organization to draw on an expanded pool of process capabilities. Access to an expanded, potentially global pool of process capabilities that can be readily configured into resource chains improves the strategic flexibility of an organization by increasing the range of responses the organization can make to a changing environment.

Modular knowledge architectures

Creating modular product and process architectures requires clearly defining what an organization knows about product and process components and their interactions. Following this basic discipline of clarifying what an organization understands in this regard improves the

ability of the organization to identify specific forms of new component or architectural knowledge that would improve the ability of the firm to create flexible product and process architectures.

Further, by virtue of their decomposition into "loosely coupled" components and activities, modular product and process architectures create loosely coupled *knowledge domains* that may facilitate learning about specific product components and organizational activities within those domains. The loose coupling of component-level designs in modular product and process architectures reduces the complexity of the context in which learning about each component can take place (Sanchez and Tarondeau, 1997). The loose coupling of component designs in modular product and process architectures may therefore facilitate discovery of less context-specific, more generalized knowledge about individual components, which may also help to identify limitations in an organization's component-level and architectural-level knowledge. In effect, the loose coupling of knowledge domains creates a *modular knowledge architecture* (Sanchez, 1996) that may enable greater precision in identifying an organization's knowledge at both component and architectural levels of understanding, thereby further improving the organization's ability to perceive opportunities for acquiring useful new forms of knowledge that improve targeting of organizational learning.

Thus, creating modular product and process architectures creates a modular knowledge architecture that improves an organization's *systemic* ability (Sanchez and Heene, 1996) to perceive and more precisely define opportunities for improving capabilities that will enlarge the strategic flexibility of the organization to manage future uncertainties.

Modular architectures as vehicles for synthesis of planning and emergence

Modular product, process, and knowledge architectures provide a framework for conceptualizing and achieving a synthesis of planning and emergence in creating and using strategic flexibility as a fundamental approach to managing an uncertain future. As previously suggested, creating basic strategic options for an organization requires planning strategies for long-term competence building, while the ability to develop and exercise specific strategic options in the near term through leveraging an organization's current competences creates opportunities for the emergence of near-term strategies. These conceptu-

alizations take more concrete form when interpreted in the context of product, process, and knowledge architectures.

Creating modular product, process, and knowledge architectures requires activities in which planning plays an essential role. An organization must study evolving markets and technologies, in the first instance, to determine the range of product and process variations the organization might usefully try to accommodate through its product and process architectures. To realize this architectural version of strategic vision or "strategic intent" (Hamel, 1989), an organization must also engage in long-term planning processes to identify and acquire new resources (including capabilities and knowledge) that will be needed to create product and process architectures with the desired level of strategic flexibility. Such planning-driven processes thereby fundamentally determine the scope of the strategic flexibilities of an organization's product, process, and knowledge architectures, because decisions made in the architecture planning process will basically determine the range of feasible responses (and their speed and cost) that an organization can make to a changing environment.

In essence, planning to create product, process, and knowledge architectures drives the creation of the basic set of strategic options that will be available to an organization in the long term, while the near-term emergent strategies of an organization will be constrained to developing and exercising specific strategic options made possible by prior planning decisions to create product, process, and knowledge architectures. All organizations make decisions that directly or indirectly, explicitly or implicitly determine the architectures of their products, processes, and knowledge. The intended creation of modular product, process, and knowledge architectures, however, may provide a vehicle for achieving an effective, coherent synthesis of long-term planning decisions to create basic strategic options with emergent near-term strategies to develop and exercise specific strategic options.

How the strategic flexibility perspective extends prior strategy theory

The recognition that resources and coordination capabilities have strategically important properties of flexibility extends the prior conceptual base of strategy theory in several important ways that improve the relevance of strategy theory to the problem of managing future uncertainties.

Prior strategy theory has not explicitly considered the flexibility properties of strategic resources. The strategic flexibility perspective described here introduces a concept of *resource flexibility* that is elaborated into dimensions of (1) the range of feasible uses of a resource in the future, (2) the cost of switching a resource from one use to another, and (3) the time required to switch a resource from one use to another. The concept of resource flexibility provides a key conceptual bridge that offers at least a partial way out of the current tautological dilemma (Sanchez and Heene, 1997) of the resource-based view in strategy theory (e.g., Barney, 1991). The criteria for identifying strategically valuable resources offered by the resource-based view are likely to be of limited usefulness in an uncertain environment. While the criteria of scarcity, inimitability, and strategic value proposed by the resource-based view may be determined retrospectively in some cases, the prospective determination of such resources is (essentially by definition) problematic for organizations facing an uncertain future.

While the resource-based view's criteria for identifying strategically important resources may have some limited *ex-post* usefulness in uncertain environments, the flexibility dimension of resources described in the strategic flexibility perspective provides some basis for assessing *ex ante* the relative strategic value of resources in an uncertain future. What recognizing the flexibility dimension of resources allows one to do is relax the implicit (but nonetheless very strong) assumption of "no significant strategic change" in the resource-based approach to identifying strategic resources. Recognizing the flexibility properties of resources permits an assessment of their relative strategic values over at least some defined range of imaginable future outcomes.

Further, although some research has addressed some organizational aspects of some forms of strategic flexibility (e.g., Harrigan, 1985), prior research has looked primarily to structural features of organizations or interorganizational arrangements as explanatory variables. The strategic flexibility perspective adds the concept of *coordination flexibility* and its elaboration into abilities of managers and others in organizations to (1) identify new uses for resources, (2) imagine new configurations of resource chains, and (3) deploy new resources effectively in a given resource chain. Thus, the concept of coordination flexibility introduces an important dimension of *managerial and organizational cognitive capabilities* into the study of strategic flexibility in responding to an uncertain future.

The recognition of the relative flexibilities of various resources and coordination capabilities provides new concepts in a new analytical framework for identifying new strategies for managing evolving opportunities and threats at the interfaces of changing technologies and markets. As the foundation for a new *strategic logic* (Sanchez and Heene, 1996), the strategic flexibility framework provides managers with a clear alternative to the logic of strategic commitment to specific courses of action (e.g., Ghemawat, 1991) that is prevalent in much strategy theory. As the *prima facie* credibility of "strategy as commitment" fades in the face of increasing future uncertainties, the appeal—and appropriateness—of the alternate logic of "strategy as strategic flexibility" increases.

Notes

1. This cost efficiency analysis could also be expanded to recognize transactions risks (Williamson, 1975), which may also be minimized when a small but flexible set of resources is internalized or made accessible through interfirm agreements. A further consideration is whether the use of flexible resources incurs any opportunity costs relative to the use of specialized assets (e.g., in the form of higher production costs or lower product-quality levels).

2. Mintzberg (1994, p. 25) also refers to an "umbrella strategy" in which the broad outlines of actions are deliberate while the details are allowed to emerge.

3. Sanchez and Mahoney (1994, 1996) observe that the specific tasks to be performed in developing and producing a product are largely determined by the specific product architecture and component designs a firm adopts. For this reason, they propose that, although organizations ostensibly design products, it is also the case that "products design organizations" in the sense that a given product design fundamentally constrains the set of feasible organization designs that can be used to develop and produce that design. Thus, the use of conventional versus modular product architectures within an organization imposes very different sets of constraints on the feasible process architectures an organization can adopt in creating and producing its products.

4. Standardization in this case means that the interface specifications are not allowed to change over some intended period of time. This stability of these standardized interface specifications is essential in creating an information structure that defines the inputs and outputs of processes that can be "mixed and matched" in a modular process architecture.

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