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EXPLICATING DYNAMIC CAPABILITIES: THE NATURE AND MICROFOUNDATIONS OF (SUSTAINABLE) ENTERPRISE PERFORMANCE

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This paper draws on the social and behavioral sciences in an endeavor to specify the nature and microfoundations of the capabilities necessary to sustain superior enterprise performance in an open economy with rapid innovation and globally dispersed sources of invention, innovation, and manufacturing capability. Dynamic capabilities enable business enterprises to create, deploy, and protect the intangible assets that support superior long- run business performance. The microfoundations of dynamic capabilities—the distinct skills, processes, procedures, organizational structures, decision rules, and disciplines—which undergird enterprise-level sensing, seizing, and reconfiguring capacities are difficult to develop and deploy. Enterprises with strong dynamic capabilities are intensely entrepreneurial. They not only adapt to business ecosystems, but also shape them through innovation and through collaboration with other enterprises, entities, and institutions. The framework advanced can help scholars understand the foundations of long-run enterprise success while helping managers delineate relevant strategic considerations and the priorities they must adopt to enhance enterprise performance and escape the zero profit tendency associated with operating in markets open to global competition. Copyright © 2007 John Wiley & Sons, Ltd.

INTRODUCTION

Recent scholarship stresses that business enterprises consist of portfolios of idiosyncratic and difficult-to-trade assets and competencies ('resources').[1] Within this framework, competitive advantage can flow *at a point in time* from the ownership of scarce but relevant and difficult-to-imitate assets, especially know-how. However, in fast-moving business environments open to global competition, and characterized by dispersion in the geographical and organizational sources of innovation and manufacturing, *sustainable* advantage requires more than the ownership of difficult-to-replicate (knowledge) assets. It also requires unique and difficult-to-replicate dynamic capabilities. These capabilities can be harnessed to continuously create, extend, upgrade, protect, and keep relevant the enterprise's unique asset base. For analytical purposes, dynamic capabilities can be disaggregated into the capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets. Dynamic capabilities include difficult-to-replicate enterprise

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[1] The reference here is to the resource-based theory of the enterprise advanced by Rumelt (1984), Wernerfelt (1984), Amit and Schoemaker (1993), and others. Some of my earlier work (Teece, 1980, 1982) was also in this vein.

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capabilities required to adapt to changing customer and technological opportunities. They also embrace the enterprise's capacity to shape the ecosystem it occupies, develop new products and processes, and design and implement viable business models. It is hypothesized that excellence in these 'orchestration'[2] capacities undergirds an enterprise's capacity to successfully innovate and capture sufficient value to deliver superior long-term financial performance. The thesis advanced is that while the long-run performance of the enterprise is determined in some measure by how the (external) business environment rewards its heritage, the development and exercise of (internal) dynamic capabilities lies at the core of enterprise success (and failure). This paper first describes the nature of dynamic capabilities, and then explicates their microfoundations.

The ambition of the dynamic capabilities framework is nothing less than to explain the sources of enterprise-level competitive advantage over time, and provide guidance to managers for avoiding the zero profit condition that results when homogeneous firms compete in perfectly competitive markets. A framework, like a model, abstracts from reality. It endeavors to identify classes of relevant variables and their interrelationships. A framework is less rigorous than a model as it is sometimes agnostic about the particular form of the theoretical relationships that may exist. Early statements of the dynamic capabilities framework can be found in Teece, Pisano, and Shuen (1990a, 1990b, 1997) and Teece and Pisano (1994). An extensive literature on dynamic capabilities now exists (e.g., Helfat *et al*., 2007) that can be organized and integrated into the general framework offered here.

As indicated, the possession of dynamic capabilities is especially relevant to multinational enterprise performance in business environments that display certain characteristics. The first is that the environment is open to international commerce and fully exposed to the opportunities and threats associated with rapid technological change. The second is that technical change itself is systemic in that multiple inventions must be combined to create products and/or services that address customer needs. The third is that there are well-developed global markets for the exchange of (component) goods and services; and the fourth is that the business environment is characterized by poorly developed markets in which to exchange technological and managerial know-how. These characteristics can be found in large sectors of the global economy and especially in high-technology sectors. In such sectors, the foundations of enterprise success today depend very little on the enterprise's ability to engage in (textbook) optimization against known constraints, or capturing scale economies in production. Rather, enterprise success depends upon the discovery and development of opportunities; the effective combination of internally generated and externally generated inventions; efficient and effective technology transfer inside the enterprise and between and amongst enterprises; the protection of intellectual property; the upgrading of 'best practice' business processes; the invention of new business models; making unbiased decisions; and achieving protection against imitation and other forms of replication by rivals. It also involves shaping new 'rules of the game' in the global marketplace. The traditional elements of business success—maintaining incentive alignment, owning tangible assets, controlling costs, maintaining quality, 'optimizing' inventories—are necessary but they are unlikely to be sufficient for sustained superior enterprise performance.

Executives seem to recognize new challenges in today's globally competitive environments and understand how technological innovation is necessary but not sufficient for success. A. J. Lafley, CEO of Proctor & Gamble, notes that 'the name of the game is innovation. We work really hard to try to turn innovation into a strategy and a process . . . '.[3] Sam Pamisano, CEO of IBM, remarks that 'innovation is about much more than new products. It is about reinventing business processes and building entirely new markets that meet untapped customer demand.'[4] Put differently, there is an emerging recognition by managers themselves that the foundations of enterprise success transcend simply being productive at R&D, achieving new product introductions, adopting best practice, and delivering quality products and services. Not only

[2] The management functions identified are analogous to that of an orchestra conductor, although in the business context the 'instruments' (assets) are themselves constantly being created, renovated, and/or replaced. Moreover, completely new instruments appear with some frequency, and old ones need to be abandoned. While flexibility is certainly an element of orchestration, the latter concept implies much more.

[3] *Fortune*, December 11, 2006: 4.

[4] *Business Week*, April 24, 2004: 64.

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must the innovating enterprise spend heavily on R&D and assiduously develop and protect its intellectual property; it must also generate and implement the complementary organizational and managerial innovations needed to achieve and sustain competitiveness.

As indicated, not all enterprise-level responses to opportunities and threats are manifestations of dynamic capabilities. As Sidney Winter (2003: 991) notes, '*ad hoc* problem solving' isn't necessarily a capability. Nor is the adoption of a well-understood and replicable 'best' practice likely to constitute a dynamic capability. Implementing best practice may help an enterprise become or remain viable, but best practices that are already widely adopted cannot by themselves in a competitive market situation enable an enterprise to earn more than its cost of capital, or outperform its competitors. Likewise, invention and innovation by themselves are insufficient to generate success (Teece, 1986).

Two yardsticks can be proposed for calibrating capabilities: 'technical' fitness and 'evolutionary' fitness (Helfat *et al*., 2007). Technical fitness is defined by how effectively a capability performs its function, regardless of how well the capability enables a firm to make a living. Evolutionary or external fitness refers to how well the capability enables a firm to make a living. Evolutionary fitness references the selection environment. Helfat *et al*. (2007) further note that both technical and evolutionary fitness range from zero to some positive value. These yardsticks are consistent with the discussion here. Dynamic capabilities assist in achieving evolutionary fitness, in part by helping to shape the environment. The element of dynamic capabilities that involves shaping (and not just adapting to) the environment is entrepreneurial in nature. Arguably, entrepreneurial fitness ought to have equal standing with evolutionary fitness.

Dynamic capabilities have no doubt been relevant to achieving competitive advantage for some time. However, their importance is now amplified because the global economy has become more open and the sources of invention, innovation, and manufacturing are more diverse geographically and organizationally (Teece, 2000), and multiple inventions must be combined to achieve marketplace success (Somaya and Teece, 2007). Achieving evolutionary fitness is harder today than it was before the millennium. Moreover, regulatory and institutional structures must often be reshaped for new markets to emerge; and as discussed later, the ubiquity of 'platforms' must now be recognized (Evans, Hagiu, and Schmalensee, 2006).

While the development and astute management of intangible assets/intellectual capital is increasingly recognized as central to sustained enterprise competitiveness, the understanding of why and how intangibles are now so critical still remains opaque and is not addressed by orthodox frameworks. What is needed is a new framework for business and economic analysis. As former U.S. Federal Reserve Chairman Alan Greenspan remarked, 'we must begin the important work of developing a framework capable of analyzing the growth of an economy increasingly dominated by conceptual products.'[5] The dynamic capabilities approach developed here endeavors to be responsive to this challenge at the enterprise level.

In an earlier treatment (Teece *et al*., 1997: 530) it was noted that 'we have merely sketched an outline for a dynamic capabilities approach.' In what follows, the nature of various classes of dynamic capabilities is identified, and an effort is made to separate the microfoundations of dynamic capabilities from the capability itself. Put differently, important distinctions are made between the organizational and managerial processes, procedures, systems, and structures that undergird each class of capability, and the capability itself. One should note that the identification of the microfoundations of dynamic capabilities must be necessarily incomplete, inchoate, and somewhat opaque and/or their implementation must be rather difficult. Otherwise sustainable competitive advantage would erode with the effective communication and application of dynamic capability concepts.

Of course, the existence of processes, procedures, systems, and structures already ubiquitously adopted by competitors does not imply that these have not in the past been the source of competitive advantage, or might not still be a source of competitive advantage in certain contexts. For example, studies of the diffusion of organizational innovations (e.g., Armour and Teece, 1978; Teece, 1980)

[5] Chairman Alan Greenspan also noted recently, 'over the past half century, the increase in the value of raw materials has accounted for only a fraction of the overall growth of U.S. gross domestic product (GDP). The rest of that growth reflects the embodiment of ideas in products and services that consumers value. This shift of emphasis from physical materials to ideas as the core of value creation appears to have accelerated in recent decades.' (Remarks of Alan Greenspan, Stanford Institute for Economic Policy Research, 2004.)

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indicate that diffusion is by no means instantaneous, and that profits can persist for many years before being competed away. Decade-long adoption cycles for new business structures and procedures (e.g., performance measurement systems) are not uncommon. Uncertain imitability (Lippman and Rumelt, 1982) may also serve to slow the diffusion process and support persistent differential performance.

Fortunately, the existing literature on strategy, innovation, and organization and the new literature on dynamic capabilities have identified a panoply of processes and routines that can be recognized as providing certain microfoundations for dynamic capabilities. For instance, Eisenhardt and Martin (2000) identify cross-functional R&D teams, new product development routines, quality control routines, and technology transfer and/or knowledge transfer routines, and certain performance measurement systems as important elements (microfoundations) of dynamic capabilities. The effort here is not designed to be comprehensive, but to integrate the strategy and innovation literature and provide an umbrella framework that highlights the most critical capabilities management needs to sustain the evolutionary and entrepreneurial fitness of the business enterprise.

SENSING (AND SHAPING) OPPORTUNITIES AND THREATS

Nature of the capability

In fast-paced, globally competitive environments, consumer needs, technological opportunities, and competitor activity are constantly in a state of flux. Opportunities open up for both newcomers and incumbents, putting the profit streams of incumbent enterprises at risk. As discussed in Teece *et al*. (1997), some emerging marketplace trajectories are easily recognized. In microelectronics this might include miniaturization, greater chip density, and compression and digitization in information and communication technology. However, most emerging trajectories are hard to discern. Sensing (and shaping) new opportunities is very much a scanning, creation, learning, and interpretive activity. Investment in research and related activities is usually a necessary complement to this activity.

Opportunities get detected by the enterprise because of two classes of factors. First, as stressed by Kirzner (1973), entrepreneurs can have differential access to existing information. Second, new information and new knowledge (exogenous or endogenous) can create opportunities, as emphasized by Schumpeter (1934). Kirzner stressed how the entrepreneurial function recognizes any disequilibrium and takes advantage of it. The Kirznerian view is that entrepreneurship is the mechanism by which the economy moves back toward equilibrium. Schumpeter, on the other hand, stressed upsetting the equilibrium. As Baumol (2006: 4) notes, 'the job of Schumpeter's entrepreneur is to destroy all equilibria, while Kirzner's works to restore them. This is the mechanism underlying continuous industrial evolution and revolution.' Equilibrium is rarely if ever achieved (Shane, 2003). Both forces are relevant in today's economy.

To identify and shape opportunities, enterprises must constantly scan, search, and explore across technologies and markets, both 'local' and 'distant' (March and Simon, 1958; Nelson and Winter, 1982). This activity not only involves investment in research activity and the probing and reprobing of customer needs and technological possibilities; it also involves understanding latent demand, the structural evolution of industries and markets, and likely supplier and competitor responses. To the extent that business enterprises can open up technological opportunities (through engaging in R&D and through tapping into the research output of others) while simultaneously learning about customer needs, they have a broad menu of commercialization opportunities. Overcoming a narrow search horizon is extremely difficult and costly for management teams tied to established problem-solving competences. Henderson (1994) notes that General Motors (GM), IBM, and Digital Equipment Corporation (DEC) encountered difficulties because they became prisoners of the deeply ingrained assumptions, information filters, and problem-solving strategies that made up their world views, turning the solutions that once made them great into strategic straitjackets.

When opportunities are first glimpsed, entrepreneurs and managers must figure out how to interpret new events and developments, which technologies to pursue, and which market segments to target. They must assess how technologies will evolve and how and when competitors, suppliers, and customers will respond. Competitors may or may not see the opportunity, and even if they

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do they may calibrate it differently. Their actions, along with those of customers, suppliers, standard-setting bodies, and governments, can also change the nature of the opportunity and the manner in which competition will unfold.

There are also constraints on the rules by which competitive forces will play out. These constraints are imposed by regulators, standard-setting bodies, laws, social mores, and business ethics. The shape of the 'rules of the game' is thus the result of co-evolution and complex interaction between what might be thought of as (business) ecosystem participants. Because of uncertainty, entrepreneurs/managers must make informed conjectures about the path ahead. These conjectures become working hypotheses that can be updated as evidence emerges. Once a new evolutionary path becomes apparent, quick action is needed.

Microfoundations

The literature on entrepreneurship emphasizes that opportunity discovery and creation can originate from the cognitive and creative ('right brain') capacities of individual(s). However, discovery can also be grounded in organizational processes, such as research and development activity. The ability to create and/or sense opportunities is clearly not uniformly distributed amongst individuals or enterprises. Opportunity creation and/or discovery by individuals require both access to information and the ability to recognize, sense, and shape developments. The ability to recognize opportunities depends in part on the individual's capabilities and extant knowledge (or the knowledge and learning capacities of the organization to which the individual belongs) particularly about user needs in relationship to existing as well as novel solutions. This requires specific knowledge, creative activity, and the ability to understand user/customer decision making, and practical wisdom (Nonaka and Toyama, 2007). It involves interpreting available information in whatever form it appears—a chart, a picture, a conversation at a trade show, news of scientific and technological breakthroughs, or the angst expressed by a frustrated customer. One must accumulate and then filter information from professional and social contacts to create a conjecture or a hypothesis about the likely evolution of technologies, customer needs, and marketplace responses. This task involves scanning and monitoring internal and external technological developments and assessing customer needs, expressed and latent. It involves learning, interpretation, and creative activity.

While certain individuals in the enterprise may have the necessary cognitive and creative skills, the more desirable approach is to embed scanning, interpretative, and creative processes inside the enterprise itself. The enterprise will be vulnerable if the sensing, creative, and learning functions are left to the cognitive traits of a few individuals.[6] Organizational processes can be put in place inside the enterprise to garner new technical information, tap developments in exogenous science, monitor customer needs and competitor activity, and shape new products and processes opportunities. Information must be filtered, and must flow to those capable of making sense of it. Internal argument and discussion about changing market and technological reality can be both inductive and deductive. Hypothesis development, hypothesis 'testing,' and synthesis about the meaning of information obtained via search are critical functions, and must be performed by the top management team. The rigorous assembly of data, facts, and anecdotes can help test beliefs. Once a synthesis of the evidence is achieved, recurrent synthesis and updating can be embedded in business processes designed by middle management and/or the planning unit in the business organization (Casson, 1997). If enterprises fail to engage in such activities, they won't be able to assess market and technological developments and spot opportunities. As a consequence, they will likely miss opportunities visible to others.

As noted in Teece *et al*. (1997), more decentralized organizations with greater local autonomy are less likely to be blindsided by market and technological developments. Because of the problem of information decay as information moves up (and down) a hierarchy, businesses must devise mechanisms and procedures to keep management informed. Bill Hewlett and David Packard developed 'management by walking about' (Packard, 1995) as a mechanism to prevent top management at Hewlett-Packard from becoming isolated from

[6] In a limited sense, that is about decision making under uncertainty. As Knight observes, with uncertainty there is 'a necessity to act upon opinion rather than knowledge' (Knight, 1921: 268). The problem is not just about knowledge asymmetries and incentive problems as Alchian and Demsetz (1972) seem to suggest. Rather, it involves filtering and interpreting information about evolving technologies and marketplaces.

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what was going on at lower levels in the enterprise, and outside the enterprise as well. In other organizations (e.g., professional services) the management ranks can be filled by leading professionals who remain involved with professional work. This protects them from the hazards of managerial isolation.

The search activities that are relevant to 'sensing' include information about what's going on in the business ecosystem. With respect to technologies, R&D activity can itself be thought of as a form of 'search' for new products and processes. However, R&D is too often usually a manifestation of 'local' search. 'Local' search is only one component of relevant search. In fast-paced environments, with a large percentage of new product introductions coming from external sources, search/exploration activity should not just be local. Enterprises must search the core as well as to the periphery of their business ecosystem. Search must embrace potential collaborators—customers, suppliers, complementors—that are active in innovative activity.

Customers are sometimes amongst the first to perceive the potential for applying new technology. Visionary members of customer organizations are often able to anticipate the potential for new technology and possibly even begin rudimentary development activities. Moreover, if the suppliers of new technology do not succeed in properly understanding user/customer needs, it is unlikely that new products they might develop will be successful. Indeed, one of the most consistent findings from empirical research is that the probability that an innovation will be successful commercially is highly correlated with the developers' understanding of user/customer needs (Freeman, 1974). Electronic computing and the Internet itself can rightly be viewed as having a significant component of user-led innovations. Business enterprises that are alert and sense the opportunity are often able to leverage customer-led efforts into new products and services, as the users themselves are frequently ill prepared to carry initial prototypes further forward.

Suppliers can also be drivers of innovation important in the final product. Innovation in microprocessor and DRAMs is a classic case. This upstream or 'component' innovation has impacted competition and competitive outcomes in personal computers, cellular telephony, and consumer electronics more generally. Failure to 'design in' new technology/components in a timely fashion will lend to failure; conversely, success can sometimes be achieved by continuous rapid 'design in.' Indeed, continuous and rapid design around new technology/components developed elsewhere can itself be a source of durable competitive advantage. Put differently, with rapid innovation by component suppliers, downstream competitive success can flow from the ability of enterprises to continuously tap into such (external) innovation ahead of the competition. External search and acquisition of technology have been going on for decades, but as Chesbrough (2003) explains, 'Open Innovation' is now a mandate for enterprise success.

The concept and practice of open innovation underscore the importance of broad-based external search and subsequent integration involving customers, suppliers, and complementors. Establishing linkages between corporations and universities assists broad-based search, as university programs are usually unshackled from the near at hand. Indeed, a recent study of patenting in the optical disk industry (Rosenkopf and Nerkar, 2001) seems to suggest that exploration that is more confined generates lower impacts, and that the impact of exploration is highest when exploration spans organizational (but not technological) boundaries. However, it is not just a matter of searching for external inventions/innovations that represent new possibilities. Frequently it is a matter of combining complementary innovations so as to create a solution to a customer problem. The systemic nature (Teece, 2000) of many innovations compounds the need for external search.

Sensing opportunities and threats can also be facilitated if the enterprise and/or the entrepreneur explicitly or implicitly employ some kind of analytical framework, as this can help highlight what is important. The field of strategic management has been stranded for some time with a framework that implicitly assumes that industry structure (and product market share), mediated by enterprise behavior, determines enterprise performance. In Porter's (1980) Five Forces framework, a good strategy involves somehow picking an attractive industry and positioning oneself to be shielded from competition. Porter's approach mandates 'industry' analysis[7] and the calibration of five distinct industry-level forces: the role of

[7] The Five Forces framework undergirds 'industry' analysis in business school curriculum and in practice. However, the very

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potential entrants, suppliers, buyers, substitutes, and rivalry amongst competitors. Because of its rather static nature and the fact that it ignores many aspects of the competitive environment including the role of complementarities, path dependencies, and supporting institutions, its application in the contexts outlined in the Introduction of this paper will limit the ability of the entrepreneur and/or the enterprise to properly sense opportunities and threats and properly calibrate strengths, weaknesses, and technological and market trajectories. If network effects, path dependencies, and the co-evolution of technologies and institutions are significant, the Five Forces framework is of limited utility.

The Five Forces framework has inherent weaknesses in dynamic environments. Fundamental is that it implicitly views market structure as exogenous, when in fact market structure is the (endogenous) result of innovation and learning.[8] Changes in science and technology create opportunities for innovation. Enterprises can search amongst new possibilities and engage in development activities. If successful, such development impacts the relative fate of firms. This in turn determines market structure. Outcomes for individual enterprises are shaped in part by the selection processes at work in the business ecosystem. Relevant factors ignored or underplayed by Five Forces include technological opportunities, path dependencies, appropriability conditions, supporting institutions, installed base effects, learning, certain switching costs, and regulation. In short, in regimes of rapid technological change with well-developed markets for goods and services (and poorly developed markets for know-how), the Five Forces framework is compromised because it has insufficient appreciation (a) for the importance of and nature of innovation and other factors that change the 'rules of the game,' (b) for factors inside the business enterprise that constrain choices, (c) for factors that impact imitation and appropriability issues, (d) for the role of supporting institutions, complementary assets, cospecialization, and network externalities, or (e) for the blurred nature of industry boundaries. Also, as discussed later, in many 'platform' industries or where there is significant outsourcing, scale is an industry asset.

The dynamic capabilities framework represents a strong break with Five Forces. Within the dynamic capabilities framework, the 'environmental' context recognized for analytical purposes is not that of the industry, but that of the business 'ecosystem'—the community of organizations, institutions, and individuals that impact the enterprise and the enterprise's customers and supplies. The relevant community therefore includes complementors, suppliers, regulatory authorities, standard-setting bodies, the judiciary, and educational and research institutions. It is a framework that recognizes that innovation and its supporting infrastructure have major impacts on competition. The dynamic capabilities framework is grounded in Kirznerian, Schumpeterian, and evolutionary theories of economic change, whereas Five Forces is grounded in the Mason–Bain paradigm of industrial economics.[9] Also, whereas according to Porter the essence of strategy formulation is 'coping with competition' (Porter, 1991: 11), in the dynamic capabilities tradition the essence of strategy involves selecting and developing technologies and business models that build competitive advantage through assembling and orchestrating difficult-to-replicate assets, thereby shaping competition itself.

Even when utilizing the ecosystem as the organizing paradigm for assessing developments in the business environment, the full import of particular facts, statistics, and developments is rarely obvious. Accordingly, the evaluative and inferential skill possessed by an organization and its management is important. Indeed, much of the information gathered and communicated inside the enterprise has minimal decision relevance. Even if relevant, it often arrives too late. Management must find methods and procedures to peer through the

concept of an industry is itself of questionable value. If industry boundaries exist, they are faint, at least in technologically progressive environments. For instance, the telecommunications 'industry' may have had distinct boundaries over half a century ago around the telegraph and the telephone and associated regulated services. However, by the 1960s, facsimile and data services had begun to be overlaid on the public telephone network. Today telephony is routinely carried by the Internet (using Voice over IP) and cable TV networks.

[8] Indeed, the (basic) market structure–conduct–performance paradigm from industrial economics that undergirds the Five Forces approach has been in need of revision for quite some time. Phillips (1971) was perhaps the first to recognize that causation is the reverse of what is assumed, with market structure being shaped by innovation.

[9] Developed in the 1930s, 1940s, and 1950s, it is still relevant to some of the 'rust belt' industries that experience low rates of technological innovation where complementors are not important, and where the coevolution of technologies and institutions is not significant (Teece, 1990).

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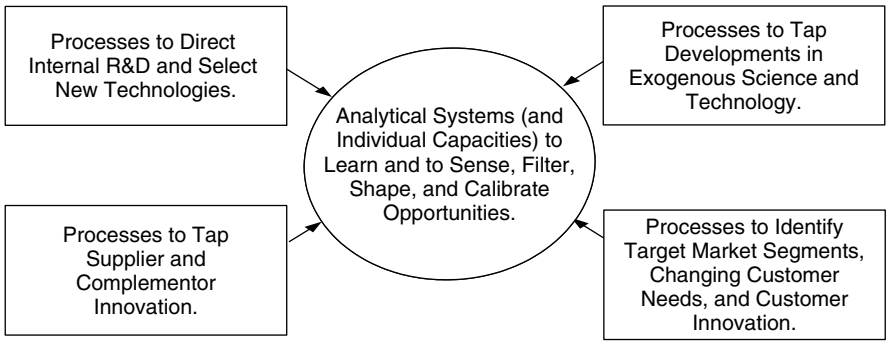

Figure 1. Elements of an ecosystem framework for 'sensing' market and technological opportunities

fog of uncertainty and gain insight. This involves gathering and filtering technological, market, and competitive information from both inside and outside the enterprise, making sense of it, and figuring out implications for action. However, because attention is a scarce resource inside the enterprise (Cyert and March, 1963), management must carefully allocate resources to search and discovery. The enterprise's articulated strategy can become a filter so that attention is not diverted to every opportunity and threat that 'successful' search reveals. Likewise, scenario planning can collapse likely situations into a small number of scenarios that can facilitate cognition, and then action, once uncertainty is resolved. Figure 1 summarizes individual and enterprise traits that undergird sensing capabilities.

SEIZING OPPORTUNITIES

Nature of the capability

Once a new (technological or market) opportunity is sensed, it must be addressed through new products, processes, or services. This almost always requires investments in development and commercialization activity. Multiple (competing) investment paths are possible, at least early on. The quintessential example is the automobile industry, where in the early days different engine technologies—steam, electric, and gasoline—each had their champions. Once a dominant design begins to emerge, strategic choices become much more limited. This paradigm, which was first offered by Abernathy and Utterback (1978) and then built upon by Teece (1986, 2007), now has considerable evidence supporting it over a wide range of technologies (Klepper and Graddy, 1990; Utterback and Suarez, 1993; Malerba and Orsenigo, 1996). It implicitly recognizes inflexion points in technological and market evolution. These inflexion points impact investment requirements and strategic choices. Implications for investment decisions have been noted elsewhere (Teece, 1986) and include staying flexible until the dominant design emerges and then investing heavily once a design looks like it can become the winner. Any strategy is, of course, likely to be fraught with hazards because of uncertainties. Moreover, the manner and time at which an enterprise needs to place its bets depend on competition in the 'input' markets and on the identity of the enterprise itself. Mitchell (1991) suggests that the timing of resource commitments can differ according to the enterprise's existing positions with respect to the relevant complementary assets. Enterprises that are well positioned can wait, while those that are not must scramble.

Addressing opportunities involves maintaining and improving technological competences and complementary assets and then, when the opportunity is ripe, investing heavily in the particular technologies and designs most likely to achieve marketplace acceptance. When network externalities are present, early entry and commitment are necessary. The presence of increasing returns means that if one network gets ahead, it tends to stay ahead. Getting ahead may require significant upfront investments. Customers will not want an enterprise's products if there are strong network effects and the installed base of users is relatively small. Accordingly, one needs to strategize around investment decisions, getting the timing right, building on increasing return advantages, and leveraging products and services from one application to another. The capacity to make high-quality,

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unbiased but interrelated investment decisions in the context of network externalities, innovation, and change is as rare as decision-making errors and biases are ubiquitous.

However, the issue that the enterprise faces is not just when, where, and how much to invest. The enterprise must also select or create a particular business model that defines its commercialization strategy and investment priorities. Indeed, there is considerable evidence that business success depends as much on organizational innovation, e.g., design of business models, as it does on the selection of physical technology. This is true at the enterprise level as well as at the economy-wide level (Nelson, 2005). Indeed, the invention and implementation of business models and associated enterprise boundary choices involve issues as fundamental to business success as the development and adoption of the physical technologies themselves. Business models implicate processes and incentives; their alignment with the physical technology is a much overlooked component of strategic management. The understanding of the institutional/organizational design issues is typically more limited than the understanding of the technologies themselves. This ignorance affords considerable scope for mistakes around the proper design of business models and the institutional structures needed to support innovation in both the private and public sectors.

In theory, one could imagine transactions between entities that scout out and/or develop opportunities, and those that endeavor to execute upon them. In reality, the two functions cannot be cleanly separated, and the activities must be integrated inside a single enterprise, where new insights about markets—particularly those that challenge the conventional wisdom—will likely encounter negative responses. The promoters/visionaries must somehow defeat the naysayers, transform internal views, and facilitate necessary investment. Some level of managerial consensus will be necessary to allow investment decisions to be made. Investment will likely involve committing financial resources behind an informed conjecture about the technological and marketplace future. However, managers of established product lines in large organizations can sometimes have sufficient decision-making authority to starve the new business of financial capital. This posture can be buttressed by capital budgeting techniques that more comfortably support investments for which future cash flow can be confidently projected. In short, the new can lose out to the established unless management is sensitive to the presence of certain biases in accepted investment decision processes. An important class of dynamic capabilities emerges around a manager's ability to override certain 'dysfunctional' features of established decision rules and resource allocation processes.

It helps to begin by recognizing that decision-making processes in hierarchically organized enterprises involve bureaucratic features that are useful for many purposes, but they nevertheless may muzzle innovation proclivities. In particular, a formal expenditure process involving submissions and approvals is characteristic of 'well-managed' companies. Decision making is likely to have a committee structure, with top management requiring reports and written justifications for significant decisions. Moreover, approvals may need to be sought from outside the organizational unit in which the expenditure is to take place. While this may ensure a matching up of expenditures to opportunities across a wider range of economic activity, it unquestionably slows decision making and tends to reinforce the status quo. Committee decision-making structures almost always tend toward balancing and compromise. But innovation is often ill served by such structures, as the new and the radical will almost always appear threatening to some constituents. Strong leaders can frequently overcome such tendencies, but such leaders are not always present. One consequence is a 'program persistence bias.' Its corollary is various forms of 'anti-innovation bias,' including the 'anti-cannibalization' basis discussed in a later section. Program persistence refers to the funding of programs beyond what can be sustained on the merits, and follows from the presence or influence of program advocates in the resource allocation process. This proclivity almost automatically has the countervailing effect of reducing funds available to new initiatives.

One should not be surprised, therefore, if an enterprise senses a business opportunity but fails to invest. In particular, incumbent enterprises tend to eschew radical competency-destroying innovation in favor of more incremental competency-enhancing improvements. The existence of layer upon layer of standard procedures, established capabilities, complementary assets, and/or administrative routines can exacerbate decision-making biases against innovation. Incumbent enterprises,

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relying on (path-dependent) routines, assets, and strategies developed to cope with existing technologies, are handicapped in making and/or adopting radical, competency-destroying, noncumulative innovation (Nelson and Winter, 1982; Tushman and Anderson, 1986; Henderson and Clark, 1990). This is true whether the competence is external to the firm or internal to the firm.

Evidence also shows that decision-makers discount outcomes that are merely probable in comparison with outcomes that are certain. This has been called the certainty effect (Kahneman and Lovallo, 1993). It contributes to excessive risk aversion when choices involve possible losses. Further, to simplify choices between alternatives, individuals generally evaluate options in isolation. Viewing each alternative as unique leads decision-makers to undervalue possibilities for risk pooling. This approach to decision making may produce inconsistent preferences and decision biases (timid choices) that lead to outcomes that block innovation (Kahneman and Tversky, 1979; Kahneman and Lovallo, 1993). An opposing bias to loss/risk aversion is excessive optimism. This leads to investment in low or negative return projects. As a result, entry decisions often fail. Audretsch (1995) found that over the period 1976–86 the average 10-year failure rate in two-digit SIC manufacturing sectors ranged from 75.8 percent to 54.8 percent. Similar failure rates have been reported in other studies (Dunne, Roberts, and Samuelson, 1988; Klepper and Miller, 1995). However, these failure rates disguise wide variation amongst particular enterprises and between new entrants and incumbents.

The existence of established assets and routines exacerbates problems of excessive risk aversion. Specifically, both the isolation effect and the certainty effect can be intensified by the existence of established assets, causing incumbent enterprises to become comparably more risk averse than new entrants. In terms of innovative activity, this excessive risk aversion leads to biased decision making and limits the probability that incumbent enterprises will explore risky radical innovations. In short, success in one period leads to the establishment of 'valid' processes, procedures, and incentives to manage the existing business. This can have the unintended effect of handicapping the new business. The proficiency with which such biases are overcome and a new opportunity is embraced is likely to depend importantly on the quality of the enterprise's routines, decision rules, strategies, and leadership around evaluating new investment opportunities. Business historians (e.g., Chandler, 1990a; Lazonick, 2005) and others have reminded us that over the long run the ability of enterprises to commit financing and invest astutely around new technologies is critical to enterprise performance.[10]

In regimes of rapid technological innovation, it is clear that making investment choices requires special skills not ubiquitously distributed amongst management teams. Nor are they ubiquitously distributed amongst investors.[11] Resource/asset alignment and coalignment issues are important in the context of innovation, but they are quite different from portfolio balance issues faced by financial investors. The presence of increasing returns means that one also needs to strategize around investment decisions, getting the timing right, building on increasing return advantages, and leveraging products and services from one application to another. Value-enhancing investments inside the knowledge-based enterprise are often cospecialized[12] to each other. Also, the nature of the portfolio 'balance' needed inside the enterprise is different from the portfolio balance sought by pure financial investors. The economics of cospecialization are not the economics of covariance with which investors are familiar. In short, the task of making astute project- and enterprise-level investment decisions is quite challenging because of cospecialization, and irreversibilities.

The project finance and related literatures provide tools and clear decision rules for project selection once cash flows are specified, uncertainty and/or risk are calibrated, and interdependencies

[10] Consider the development of civilian jet transport aircraft in the United States in the 1950s. As Phillips (1971: 126) noted: 'Any one of Boeing, Douglas, Lockheed, or Corvair might have been first. . . . The technology was there to adapt to—not risklessly or costlessly to be sure, but it was there. Perhaps the biggest risk in 1953 was not technological in character. Instead, it was risk with respect to what sort of jet to build and when to build it.'

[11] The decision skills required of management have limited commonality with those of an investor. One difference is the illiquidity and irreversibility of most managerial investment decisions. Another is the need to achieve continuous alignment amongst the assets at work in the enterprise. Both public and private equity investors typically lack this kind of orchestration and integration capability or capacity. Moreover, their skills are most applicable when investments are liquid.

[12] Cospecialization is defined and discussed in Teece (1986) and explored further in the section below entitled 'Managing threats and reconfiguration.'

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between and amongst cash flows are ignored. However, the essence of the investment decision for the (strategic) manager is that it involves estimating interdependent future revenue streams and cost trajectories, and understanding a panoply of continuous and interrelated cospecialized investment issues.[13] The returns to particular cospecialized assets cannot generally be neatly apportioned or partitioned. As a result, the utility of traditional investment criteria is impaired. Thus while project-financing criteria (e.g., discounted cash flow, payback periods and the like) and techniques for decision making under uncertainty are well known, there is little recognition of how to value intangibles and take into account features such as cospecialization, irreversibility, and opportunity costs.[14] Nor is the concept of a 'strategic investment' recognized in the finance literature. Finance theory provides almost no guidance with respect to how to estimate future cash flows, although making such estimates is as much, if not more, the essence of good decision making as are the methodologies and procedures for analyzing cash flow.

In short, managers need to make unbiased judgments under uncertainty around not just future demand and competitive responses associated with multiple growth trajectories, but also around the pay-offs from making interrelated investments in intangible assets. In the world of tangible assets, this can sometimes be precisely modeled; not so for the world of cospecialized intangibles. In essence, the organizational challenge appears to be that in environments experiencing rapid change, activities are not fully decomposable. Cross-functional activities and associated investments must take place concurrently, rather than sequentially, if enterprises are to cut time-to-market for new products and processes. Managerial judgments (decision-making skills) take on great significance in such contexts. This was also true during prior centuries, as Alfred Chandler's (1990a, 1990b) analysis of successful enterprises from the 1870s through the 1960s makes apparent. No matter how much analytical work is done, tacit investment skills are of great importance. Chandler further argues that success in the late-nineteenth and much of the twentieth century came to those enterprises that pursued his 'three-pronged' strategy: (1) early and large-scale investments behind new technologies; (2) investment in product-specific marketing, distribution, and purchasing networks; and (3) recruiting and organizing the managers needed to supervise and coordinate functional activities. The first and second elements require commitment to investments where irreversibilities and cospecialization are identified. While the nature of required investments may have changed in recent decades (less decomposable/more interrelated), investment decision skills remain important.

Microfoundations

Selecting product architectures and business models

The design and performance specification of products, and the business model employed, all help define the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit. They reflect management's hypothesis about what customers want and how an enterprise can best meet those needs, and get paid for doing so. They embrace: (1) which technologies and features are to be embedded in the product and service; (2) how the revenue and cost structure of a business is to be 'designed' and if necessary 'redesigned' to meet customer needs; (3) the way in which technologies are to be assembled; (4) the identity of market segments to be targeted; and (5) the mechanisms and manner by which value is to be captured. The function of a business model is to 'articulate' the value proposition, select the appropriate technologies and features, identify targeted market segments, define the structure of the value chain, and estimate the cost structure and profit potential (Chesbrough and Rosenbloom, 2002: 533–534). In short, a business model is a plan for the organizational and financial 'architecture' of a business. This model makes assumptions about the behavior of revenues and costs, and likely customer and competitor behavior. It outlines the contours of the solution required to earn a profit, if a profit is available to be earned. Once adopted it defines the way the enterprise 'goes to market.' Success requires

[13] Monteverde and Teece's (1982) study of the automobile industry showed that 'systems integration' considerations impacted make–buy decisions. This evidence hints at the value to be created from figuring out heuristics and protocols likely to aid decisions involving interrelated investments. Evans, Hagiu, and Schmalensee (2006) recognize multisided market interdependencies which likewise require a systems perspective.

[14] Ghemawat (1991) and many others have examined uncertainty and irreversibilities. However, cospecialization has received very little attention.

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that business models be astutely crafted. Otherwise, technological innovation will not result in commercial success for the innovating enterprise. Generally there is a plethora of business models that can be designed and employed, but some will be better adapted to the ecosystem than others. Selecting, adjusting, and/or improving the business model is a complex art.

Nevertheless, the importance of 'business models' has been given short shrift in the academic literature, at least until quite recently. Important (business model) choices include technological choices, market segments to be targeted, financial terms (e.g., sales vs. leasing), choices with respect to bundled vs. unbundled sales strategies, joint ventures vs. licensing vs. go-it-alone approaches, etc. For example, in the early days of the copier industry, Xerox focused on leasing rather than selling copiers. This stemmed from a belief that customer trial would lead to further use. Another example from the United States is Southwest Airlines, which believes that most customers want low frills, reliability, and low cost. It eschews the hub-and-spoke model, does not belong to any alliances, and does not allow interlining of passengers and baggage. Nor does it sell tickets through travel agencies—all sales are direct. All aircraft are Boeing 737s. Its business model is quite distinct from the major carriers, although many have tried (without much success) to copy elements of the Southwest model.[15]

The capacity an enterprise has to create, adjust, hone, and, if necessary, replace business models is foundational to dynamic capabilities. Choices around how to capture value all help determine the architecture or design of a business. Having a differentiated (and hard-to-imitate) yet effective and efficient 'strategic architecture' to an enterprise's business model is important. Both Dell Inc. and Wal-Mart have demonstrated the value associated with their business models (Webvan and many other dot-coms demonstrated just the opposite). Both Dell Inc.'s and Wal-Mart's business models were different, superior, and hard for competitors to replicate. They have also constantly adjusted and improved their processes over time.[16]

One might be tempted to argue that designing, implementing, and validating business models is straightforward, but this simply is not so. Aspects of designing (and redesigning) a business model are undoubtedly readily routinized and codified. Note the plethora of business books providing instruction on how to write a business plan. Such manuals can provide some discipline to the business model questions that one should ask. However, designing a new business requires creativity, insight, and a good deal of customer, competitor, and supplier information and intelligence. There is a significant tacit component. Entrepreneurs and executives are forced to make many informed guesses about customer and competitor behavior, as well as the behavior of costs. Indeed, validating a business model and a business plan requires both effort and judgment. It takes detailed fact-specific inquiry including: a keen understanding of customer needs and customer willingness to pay; an understanding of procurement cycles and the sales cycle; knowledge of supply and distribution costs; and an understanding of competitor positioning and likely competitive responses. Put differently, selecting the right 'architecture' for a business requires not just understanding the choices available; it also requires assembling the evidence needed to validate conjectures and hunches about costs, customers, competitors, complementors, distributors, and suppliers.

Designing good business models is in part 'art.' However, the chances of success are greater if enterprises (1) analyze multiple alternatives, (2) have a deep understanding of user needs, (3) analyze the value chain thoroughly so as to understand just how to deliver what the customer wants in a cost-effective and timely fashion, and (4) adopt a neutrality or relative efficiency perspective to outsourcing decisions. Useful tools include market research and transaction cost economics. Chesbrough and Rosenbloom (2002) suggest that established enterprises often have blinders

[15] Let us take another example. A rock star might decide to use concerts as the key revenue generator, or the concert may be used primarily to stimulate sales of recordings. The star could decide to spend less time performing at concerts, and more time in the recording studio. There is clearly a choice of various media to extract value: live productions, movies, sale of CDs through stores, online sale of music through virtual stores such as the iTunes store offered by Apple, etc. The emergence of the Internet, Napster, and Napster clones in turn requires artists (and record companies) to rethink their business models. The ability to reconfigure business models for delivering and pricing music profitably is undoubtedly a dynamic capability for both the record companies and the artists.

[16] Indeed, a critical element of Dell's success is not just the way it has organized the value chain, but also the products that it decides to sell through its distribution system. The initial products were personal computers, but now include printers, digital projectors, and computer-related electronics.

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with respect to alternative business models—and that this prevails even if the technology is spun off into a separate organization, where other (path-dependent constraints) are less likely to exist.

In short, designing the business correctly, and figuring out what John Seeley Brown refers to as the 'architecture of the revenues'[17] (and costs), involve processes critical to the formation and success of new and existing businesses. No amount of good governance and leadership is likely to lead to success if the wrong business model is in place. Good business models achieve advantageous cost structures and generate value propositions acceptable to customers. They will enable innovators to capture a large enough portion of the (social) value generated by innovation[18] to permit the enterprise at least to earn its cost of capital.

Selecting enterprise boundaries

In regimes of rapid technological progress, setting the enterprise boundaries correctly is important, and can be viewed as an element of getting the business model right. In Teece (1986), Chesbrough and Teece (1996), and Teece (1986, 2007) normative rules were advanced indicating how enterprise boundaries ought to be set to ensure that innovation is more likely to benefit the sponsor of the innovation rather than imitators and emulators. Key elements of this framework were: (1) the appropriability regime (i.e., the amount of natural and legal protection afforded the innovation by the circumstances prevailing in the market); (2) the nature of the complementary assets (cospecialized or otherwise) that an innovating enterprise possessed; (3) the relative positioning of innovator and potential imitators with respect to complementary assets; and (4) the phase of industry development (pre or post the emergence of a dominate design). The framework is prescriptive not only as to strategy but also as to outcomes.

Enterprise boundary decisions need to reflect other criteria too. A company's integration upstream, downstream, as well as externally, is partly driven by the need to build capabilities, particularly when such capabilities are not widely distributed in the industry. Of course, vertical specialization is not itself independent of enterprise strategy, and vice versa (Macher and Mowery, 2004). Studies of the early vertical evolution of the petroleum industry stressed the need to align upstream and downstream capacities in an environment where qualified business partners were limited (Teece, 1976). Pisano, Shan, and Teece (1988: 202) developed a framework for understanding R&D outsourcing that recognized that the locus of world-class research/productive capability might lie external to the enterprise, requiring outsourcing as a way to compete.[19] Jacobides and Winter (2005: 398) have also clearly stated that 'it is necessary to look at the distribution of productive capabilities—to understand when enterprises are integrated and when they are not. It becomes clear that vertical specialization must be in part a function of heterogeneity in productive capabilities along the value chain.' They also note that the capability development process itself changes as a consequence of changing scope. Recognition that systemic innovation favors integration, for both transaction costs and capability reasons, is also embedded in the saga of the development of the diesel electric locomotive (Teece, 1988). The ability of enterprises to procure technology externally as well as develop it internally are critical skills, as discussed above and in Teece (1986), Chesbrough and Teece (1996), and Teece (2000). Firms must dispel prejudices against technology from the outside, and hone their absorptive capacity through learning activities and skill accumulation. Enterprises may require alliance arrangements to actively learn and upgrade relevant skills (Branzei and Vertinsky, 2006).

The critical strategic element associated with capturing value from innovation is the ability of the innovating enterprise to identify and control the 'bottleneck assets' or 'choke points' in the value chain from invention through to market (Teece, 1986, 2006). Outsourcing those assets/services that

[17] Quoted in Chesbrough and Rosenbloom (2002: 529).

[18] A recent effort to establish a new business model is exemplified by the efforts of Rambus to rely exclusively on patent licensing to capture value from its significant technological contributions to the design of semiconductor memory devices. Such an approach avoids building fabrication facilities (which are extremely expensive) but its viability depends entirely on Rambus's ability to enforce its patents in an environment in which courts are sometimes reluctant to enjoin infringers and where enforcing broad patents may engender antitrust challenges.

[19] The model identified transaction costs, the locus of capabilities (inside or outside the enterprise), and appropriability regimes as three relevant classes of factors driving enterprise boundary decisions. In particular, it was noted that transaction cost factors 'must be weighed against any losses in productive efficiency that result from being less skilled than specialists in the relevant stages of production.'

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are in competitive supply is, of course, consistent with such a strategy. In short, the boundaries of the enterprise need to be artfully contoured for each major innovation, using decision criteria referenced above. Failure to do so is likely to be associated with the failure to stimulate market development (especially of complementary technologies) and incomplete capture of the profits available from innovation.

Managing complements and 'platforms'

Investment choices in many high-technology industries today are driven by imperatives quite different from the (industrial) contexts that have animated strategy research over the past half century. Scale and scope economy 'mandates,' which to some strategists dictate the scale and scope of the enterprise, have given way to a different set of mandates around developing (or encouraging) complementary investments and capturing cospecialization benefits. The reason for this is that in many industries outsourcing has made scale an industry asset, in the sense that economies of scale can be captured by outsourcing to contract manufacturers who, in the face of competition, pass on the benefits of scale. Witness the contract semiconductor fabricators. They enable fabless semiconductor 'designers' to capture most of the benefits of scale without engaging in manufacturing. Likewise, in the clothing industry, small-scale designers of footwear and outerwear can source at competitive rates from large suppliers, thereby capturing the benefit of scale economics previously enjoyed only by large integrated manufacturers. With competition, scale advantages are not proprietary, and are unlikely to be a source of sustainable differentiation.

When intermediate (product) markets are well developed, neither economies of scale nor economies of scope need define the scale and scope of the enterprise. Contractual access (on competitive terms) to scale-based 'facilities' vitiates the need for enterprise scale and scope. This was the major theme in Teece (1980) but the importance of the argument was often not appreciated. Today its importance is more evident.

While the importance of scale and scope economies to enterprise boundary decisions may have been softened, the significance to enterprise strategy of cospecialization has been elevated. As viewed by customers, high-technology 'products' are often systems. These systems consist of interdependent components resting on 'platforms.' There is strong functional interdependence amongst components of the system. End user demand is for the system, not the platform. There is often a multisided 'market' phenomenon at work as well. For instance, electronic game consoles are not much use without games; computer operating systems are not much use without a suite of application programs; credit cards are not much use to cardholders without merchants that will accept them, and vice versa; and hydrogen cars are not much use without hydrogen filling stations, and vice versa. This important class of situations has highlighted the importance of cospecialization, and strategic decision making must now take this into account.

The phenomenon is not new—the automobile industry depended first on the general store and then specialized retail outlets to make gasoline ubiquitously available to motorists. The role of complementary assets and cospecialization has already been recognized in the innovation process, and a decision framework outlined to chart the innovator on a course more likely to lead to a higher share of the available profit (Teece, 1986, 2007). What is new is that complements often sit on top of what might be thought of as 'platforms,' which are managed by an incumbent enterprise (Evans *et al*., 2006). In these circumstances, entry decision and 'boundary' conundrums exist. The platform owner needs complementary products to be provided by others, particularly when it has little or no relevant skills to develop them itself. Fostering innovation and entry by the providers of complementary products may, in fact, require the platform manager to commit (by word or deed) not to provide certain complements. When the interface between the complementors and the platform is itself evolving, decision rules become ever more complex. The platform owner and the complementors might also need to consider whether the platform needs to be open or proprietary, and whether tools and other incentives should be provided to stimulate investment by the complementors. Decision frameworks that recognize the importance of network effects, dispersion in the sources of innovation of complementary products, interoperability issues, and installed base trajectories must all be factored into decisions. Quality decisions will require uncommon foresight and the ability to shape outcomes. In this regard, the existing asset

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base of the platform manager, including its financial resources, is of considerable significance. The distribution of (development) capabilities between the platform manager and the complementors will also be important. Also, as discussed below, the boundaries of the enterprise (i.e., whether the platform manager is also providing complements) is likely to be of significance, possibly deterring (or encouraging) entry and innovation by complementors.

Avoiding bias, delusion, deception, and hubris[20]

As noted, proclivities toward decision errors are not uncommon in managerial decision making, particularly in large organizations. Investment decision errors already identified include excessive optimism, loss aversion, isolation errors, strategic deception, and program persistence. As Nelson and Winter (2002: 29) note, organizational decision processes often display features that seem to defy basic principles of rationality and sometimes border on the bizarre. These errors can be especially damaging in fast-paced environments with path dependencies and network effects, as there is less opportunity to recover from mistakes. When investments are small and made frequently, there are many opportunities to learn from mistakes. Since large investments are usually occasional, major investment decisions are likely to be (potentially) more vulnerable to error.

Fortunately, biases can be recognized ahead of time. Enterprises can bring discipline to bear to purge bias, delusion, deception, and hubris. However, the development of disciplines to do so is still in its infancy. The implementation of procedures to overcome decision-making biases in enterprise settings is, accordingly, not yet a well-distributed skill, and may not be for decades to come. Accordingly, competitive advantage can be gained by early adopters of techniques to overcome decision biases and errors.

Overcoming biases almost always requires a cognitively sophisticated and disciplined approach to decision making. Being alert to the incentives of the decision-makers and to possible information asymmetries is a case in point. Obtaining an 'outside view' through the review of external data can help eliminate bias. Testing for errors in logic is also essential. Management also needs to create an environment where the individuals involved in making the decision, at both the management and board level, feel free to offer their honest opinions, and look at objective (historical) data in order to escape from closed thinking. Incentives must also be designed to create neutrality when assessing investments in the old and the new.

Considerable progress in combating biases has been made. Advisors call upon managers to adopt radical, nonformulaic strategies in order to overcome the inertias that inhibit breakthrough innovation (Davidow and Malone, 1992; Handy, 1990). Specifically, corrective strategies encourage change through two basic mechanisms: (1) designing organizational structures, incentives and routines, to catalyze and reward creative action; and (2) developing routines to enable the continual shedding of established assets and routines that no longer yield value. Strategies that provide structures, incentives, and processes to catalyze and reward creative action serve to attenuate problems of excessive risk aversion. For example, strategies that call on the enterprise to 'cut overhead' and 'increase divisional authority' can be interpreted as efforts to reduce the number of management layers of the enterprise and to push decision making down to lower levels to minimize the inherent isolation errors associated with multilevel, hierarchical decision-making processes. These recommendations can be viewed as organizational processes and strategic mechanisms to mitigate decision-making biases.

Perhaps most importantly, executives must acknowledge the interaction effect between owning established assets and decision-making biases. Many recommended strategies (such as cannibalizing profitable product lines and licensing your most advanced technology) call for the shedding of established capabilities, complementary assets and/or administrative routines to reduce the intensity of decision-making biases. By jettisoning 'dead' or dying assets, the enterprise is no longer shackled with an asset base that can be a crutch and provide a false sense of security, and sustain groups inside the enterprise that persist in torpedoing new initiatives. In abandoning dead or dying assets, the enterprise frees itself of certain routines, constraints, and opportunities for undesirable protective action inside the enterprise.

Sources of the 'anti-cannibalization' bias mentioned earlier can also be attacked. Self-serving

[20] I would like to thank Dan Lovallo for inspiration and help in this section.

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behavior inside the enterprise to 'protect' incumbent constituencies undergirds this bias. Flawed investment frameworks may also contribute. Entry into a market by an enterprise with a new and superior technology will cause rapid depreciation of the economic value of an incumbent's plant and equipment. However, the incumbent may well make business decisions based on examining accounting profits that reflect depreciation rates specified by accepted accounting standards. If decision-makers confuse depreciation calculated according to generally accepted accounting principles (GAAP) with real economic depreciation, and conclude that the existing business is still profitable when, in fact, it is not, then the business enterprise may eschew profit-enhancing cannibalization of its own products. To guard against this bias, investment decision-makers and incumbents must use accounting data cautiously. In particular, they must also consider the opportunity cost associated with not cannibalizing their own products. Capital-budgeting procedures implicitly biased against projects with long-term horizons must be jettisoned or used cautiously. That is not to say that incumbents need to invest on the same schedule as new entrants. As Teece (1986) and Mitchell (1991) demonstrate, incumbents need not be the first movers. Superior positioning in complementary assets may enable incumbents to let the new entrants do the prospecting, investing later once market and technological risk has diminished.

There is an obvious role for leadership in making quality decisions, communicating goals, values, and expectations, while also motivating employees and other constituencies. Organizational identification (and commitment, which is the corollary) can dramatically augment enterprise performance, although it is doubtful it can override completely misaligned incentives. Nevertheless, group loyalty is a 'powerful altruistic force' that conditions employee goals and the cognitive models they form of their situation (Simon, 1993: 160). Top management through its action and its communication has a critical role to play in garnering loyalty and commitment and achieving adherence to innovation and efficiency as important goals. Since there is already an extensive literature on culture, commitment, and leadership, these issues are not discussed further. However, it would be a significant oversight in a summary statement of the dynamic capabilities framework to ignore them completely. Their full integration into the framework is left to others. However, it is recognized that to the extent such properties are not ubiquitously distributed amongst business enterprises, they can be a very important source of superior performance. Figure 2 summarizes the microfoundations identified in this section of the paper.

MANAGING THREATS AND RECONFIGURATION

Nature

The successful identification and calibration of technological and market opportunities, the judicious selection of technologies and product attributes, the design of business models, and the

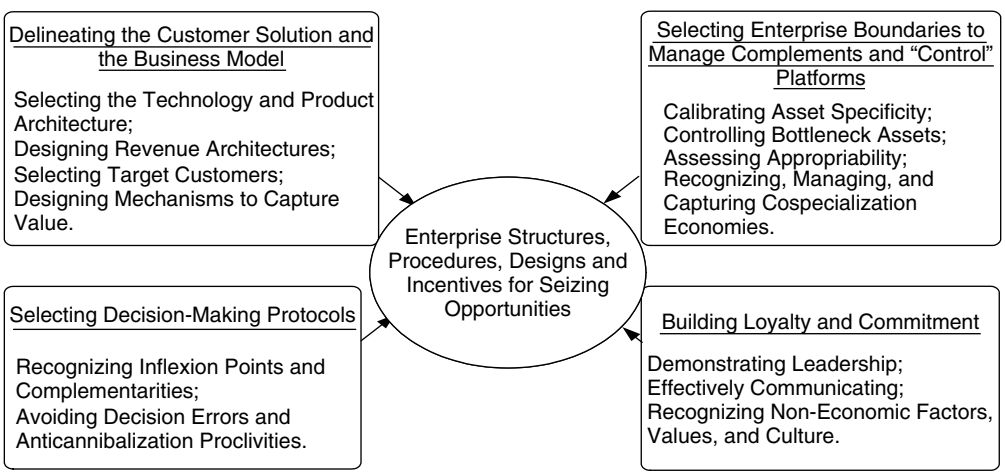

Figure 2. Strategic decision skills/execution

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commitment of (financial) resources to investment opportunities can lead to enterprise growth and profitability. Profitable growth will lead to the augmentation of enterprise-level resources and assets. Success will cause the enterprise to evolve in a path-dependent way. A key to sustained profitable growth is the ability to recombine and to reconfigure assets and organizational structures as the enterprise grows, and as markets and technologies change, as they surely will. Reconfiguration is needed to maintain evolutionary fitness and, if necessary, to try and escape from unfavorable path dependencies. In short, success will breed some level of routine, as this is necessary for operational efficiency. Routines help sustain continuity until there is a shift in the environment. Changing routines is costly, so change will not be (and should not be) embraced instantaneously. Departure from routines will lead to heightened anxiety within the organization, unless the culture is shaped to accept high levels of internal change. If innovation is incremental, routines and structures can probably be adapted gradually or in (semi-continuous) steps. When it is radical, possibly because it is science based, then there will be a mandate to completely revamp the organization and create an entirely new 'break out' structure (Teece, 2000) within which an entirely different set of structures and procedures is established.

As discussed earlier, the 'anti-cannibalization' bias is a particular manifestation of incentive and structural problems that can thwart innovation in established enterprises. Incumbent enterprises possessing fixed assets may further tend to limit their new investments to innovations that are 'close-in' to the existing asset base. They tend to narrowly focus search activities to exploit established technological and organizational assets. This effect makes it difficult for these enterprises to see potential radical innovations. In addition, incumbent enterprises tend to frame new problems in a manner consistent with the enterprise's current knowledge base, assets, and/or established problem-solving heuristics and established business model. This second effect means that managers may not successfully address opportunities or potential innovations even when they do recognize them. Managers face and must overcome at least two constraints—cognitive limitations and framing biases—arising from established assets (Teece, 2000).

As the enterprise grows, it has more assets to manage and to protect against malfeasance and mismanagement. Shirking, free riding, the strategic manipulation of information, and internal complacency are all issues that established enterprises will confront continuously. As discussed earlier, over time successful enterprises will develop hierarchies and rules and procedures (routines) that begin to constrain certain interactions and behaviors unnecessarily. Except in very stable environments, such rules and procedures are likely to require constant revamping if superior performance is to be sustained. It is not uncommon to find that a once functional routine becomes dysfunctional, providing inertia and other rigidities that stand in the way of improved performance (Leonard-Barton, 1995; Rumelt, 1995). As a result, less well-resourced enterprises (sometimes established enterprises that have divested certain assets, sometimes new entrants) end up winning in the marketplace.

Traditional management approaches endorse strong hierarchies with at least three levels of management: top, middle, and lower. Control is exerted at the top and cascades down through multiple levels. Employees tend to end up beholden to the management and CEO, and not the customer. The existence of independent profit centers can lead to internal boundaries that stand in the way of providing integrated solutions that benefit customers. With centralized structures, strategic decisions made at the top tend to become isolated from marketplace realities. Customer care is relegated to employees who are lower down in the organization. In short, the systems and rules needed to manage many layers of organization tend to create structural rigidities and perversities that in turn handicap customer and technological responsiveness. To sustain dynamic capabilities, decentralization must be favored because it brings top management closer to new technologies, the customer, and the market.

Top management leadership skills are required to sustain dynamic capabilities. An important managerial function is achieving semi-continuous asset orchestration and corporate renewal, including the redesign of routines. This is because the sustained achievement of superior profitability requires semi-continuous and/or continuous efforts to build, maintain, and adjust the complementarity of product offerings, systems, routines, and structures. Inside the enterprise, the old and the new must

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complement. If they do not, business units must be disposed of or placed in some type of separate structure. Otherwise, work will not proceed efficiently, and conflicts of one kind or another will arise. Put differently, periodic if not continuous asset orchestration—involving achieving asset alignment, coalignment, realignment, and redeployment—is necessary to minimize internal conflict and to maximize complementarities and productive exchange inside the enterprise.

Redeployment and reconfiguration (Capron, Dussauge, and Mitchell, 1998) may also involve business model redesign as well as asset-realignment activities, and the revamping of routines. Redeployment can involve transfer of nontradable assets to another organizational or geographic location (Teece, 1977, 1980). It may or may not involve mergers, acquisitions, and divestments.[21] Helfat and Peteraf (2003: 1006) suggest that capability redeployment takes one of two forms: the sharing of capability between the old and the new, and the geographic transfer of capability from one market to another. Both are possible, but neither is easy.

Microfoundations

Achieving decentralization and near decomposability

Every system comprises subsystems (elements) that are to some extent interdependent and independent. However, as discussed earlier, enterprises are unlikely to be continuously responsive to customers and new technologies absent a high degree of decentralization. With decentralized decision making, different managers observe different information and control different decisions, but there is not the need for communication to a single central decision-maker, and hence no comprehensive 'roll-up' of information is required. Decentralization must be pursued as enterprises expand, otherwise flexibility and responsiveness will erode.

One well-documented restructuring that is widely adopted as enterprises grow is the adoption of the multidivisional form. This involves decomposition and the devolution of decision rights to quasi-independent profit centers. The abandonment of functional structures in favor of the multidivisional form has been analyzed by Chandler (1962), Williamson (1975), and many others. The basic rationale of this reconfiguration was to achieve greater accountability of managerial decisions so that the recognition of opportunities and threats could proceed more thoroughly and expeditiously. With functional internal structures, day-to-day problems tend to distract management from long-run strategic issues. Studies showed that decentralization along product or market lines with independent profit centers led to performance improvements in many industries, at least during the period in which these organizational innovations were diffusing (Armour and Teece, 1978; Teece, 1980, 1981). More recent scholarship has suggested that even further decentralization and decomposition in large organizations may be beneficial (Bartlett and Ghoshal, 1993). There is also some evidence that 'modern' human resource management techniques—involving delayering, decentralization of decision rights, teamwork, flexible task responsibilities and performance-based rewards—also improve performance (Jantunen, 2005).

Of course, achieving decentralization can compromise the organization's ability to achieve integration. There is little harm and much benefit from decentralization when the customer does not benefit from an integrated product offering, or when sourcing and other inputs do not benefit from integration and/or aggregation. If customer and supply considerations allow decomposability (because the required integration between units is less than within units), then management's ability to identify and implement decomposable subunits should enhance performance. However, if firm-specific economies of scale and scope are available, they must be captured—otherwise the enterprise is tantamount to a conglomerate. This tension can be managed through a collaborative nonhierarchical management style assisted by establishing councils and other integration forums. Middle management can also play a critical role when such forums are established. They can also design and implement tight financial controls and performance-based reward systems. Since intangibles are key drivers of performance, their enhancement and protection must become a managerial priority.

The open innovation model of Chesbrough (2003) also recognizes the benefits of relying on

[21] As Capron *et al*. (1998) explain, failures in the market for resources sometimes cause enterprises to buy and sell business. What they refer to as market failure appears to relate to the 'thin market' problem discussed by the author in this paper and elsewhere (Helfat *et al*., 2007).

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a distributed model of innovation where the enterprise reaches out beyond its own boundaries to access and integrate technology developed by others. By way of example, Henderson and Cockburn (1994) found that an enterprise's ability to integrate knowledge from external sources—their 'architectural competence'—was positively associated with research productivity, as measured by patent counts. Likewise, Iansiti and Clark (1994) found that 'integration capability' in the automobile industry and in the computer industry was associated with positive enterprise performance, again demonstrating the importance of knowledge integration skills. In the end, it appears that in fast-paced environments organizational units must have considerable autonomy (to make decisions rapidly) but remain connected to activities that must be coordinated. Achieving this delicate balance is what Simon (2002) called 'near decomposability' and implementing it is an important microfoundation of dynamic capabilities.

Managing cospecialization

The field of strategic management and the dynamic capabilities framework recognizes that 'strategic fit' needs to be continuously achieved. However, unless the concept is operationalized it has limited utility. The key dimension of 'fit' emphasized in the dynamic capabilities framework is that of 'cospecialization.' The concept of cospecialization, introduced in Teece (1986) and discussed in the 'Managing complements and "platforms"' section above, operationalizes at least one dimension of the otherwise rather vague concept of organizational adaptation and 'fit.' Cospecialization can be of one asset to another, or of strategy to structure, or of strategy to process. It is important to both seizing and reconfiguration. In environments of rapid change, there is a need for continuous or at least semi-continuous realignment.

In many ways, much of the traditional literature on organizational adaptation and 'fit' (e.g., Miles and Snow, 1994) is consistent with dynamic capabilities. In particular, both the strategy and organizational behavior literature emphasize fit between and amongst strategy, structure, and processes. While it is not central to his framework, Michael Porter does note that:

> [S]trategic fit among many activities is fundamental not only to competitive advantage but also to sustainability of that advantage. It is harder for a rival to match an array of interlocked activities than it is merely to imitate a particular sales force approach, match a process technology, or replicate a set of product features. (Porter, 1996: 73)

Despite Porter's clear recognition of the concept of 'fit,' neither complementarities nor cospecialization are recognized in the Five Forces framework. However, complementarities and cospecialization are recognized in various ways in Teece (1986, 2000, 2006, 2007), Brandenburger and Nalebuff (1996), and Santoro and McGill (2005). Economic historians (Rosenberg, 1982; Hughes, 1983) have also noted the phenomenon at a general level; but in most analyses of competition and competitive advantage, it is common to stress that various innovations are substitutes, rather than complements that may be cospecialized to each other. Indeed, Schumpeter (1934) stressed that successful innovations/enterprises are threatened by swarms of imitators, all striving to produce 'me-too' substitutes.[22] He completely neglected complementarities.

However, complementary innovation and complementary assets are of great significance, particularly in industries in which innovation might be characterized as cumulative, and/or where industry 'platforms' exist or are needed. Examples of complementary innovation are ubiquitous. In the enterprise software industry, business applications can be especially valuable to users if they can somehow be integrated into a single program, or into a tightly integrated suite. The development of gyroscopic stabilizers made imaging devices such as video cameras and binoculars easier to use by minimizing the impact of camera shake, and enhanced the product, especially when the new feature was able to be introduced at low cost. Likewise, better high-energy rechargeable batteries enable laptop computers and cell phones to operate for longer times. Situations of complementarities where there is also cospecialization between technologies, and between technologies and other parts

[22] Schumpeter wrote (1934: 223) that innovations/new combinations carried out by entrepreneurs 'are not, as one would expect according to general principles of probability, evenly distributed through time ... but appear, if at all, discontinuously in groups or swarms.' This 'swarming' of innovations and innovative activity occurs 'exclusively because the appearance of one or a few entrepreneurs facilitates the appearance of others, and these the appearance of more, in even increasing number' (Schumpeter, 1934: 228). Recent studies that analyze patent races have also reinforced the view that innovations are substitutes, not complements.

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of the value chain, are common, yet until recently poorly analyzed in economic analysis and in strategy formulation.

Cospecialized assets are a particular class of complementary assets where the value of an asset is a function of its use in conjunction with other particular assets.[23] With cospecialization, joint use is value enhancing.[24] Cospecialization results in 'thin' markets; i.e., the assets in question are idiosyncratic and cannot be readily bought and sold in a market. Capturing cospecialization benefits may require integrated operations (Teece, 1980). Cospecialization allows differentiated product offerings or unique cost savings. The inherent 'thin' market environment surrounding specific assets means that competitors are not able to rapidly assemble the same assets by acquisition, and hence cannot offer the same products/services at competing price points.

Management's ability to identify, develop, and utilize in combination specialized and cospecialized assets built or bought is an important dynamic capability, but it is not always present in enterprise settings. Special value can be created (and potentially appropriated by another party) through asset combinations, particularly when an asset owner is not cognizant of the value of its assets to another party that owns assets whose value will be enhanced through combination.[25] This arises because the markets for cospecialized assets are necessarily thin or nonexistent. Langlois (1992) highlights the case of the diesel-electric locomotive where, in the 1920s, Charles Kettering had developed advanced lightweight diesel technology at the GM labs. The earliest use was in submarines. Alfred P. Sloan, GM's chairman, saw the possibility of applying the technology to make diesel-electric locomotives—steam power was, at the time, completely dominant. To accomplish this, GM needed capabilities resident in the locomotive manufacturers and at Westinghouse Electric. Langlois (1992: 115) notes that the three sets of capabilities might have been combined by some kind of contract or joint venture, but the steam manufacturers—Alco, Baldwin, and Lima—failed to cooperate.[26] In short, both innovation and reconfiguration may necessitate cospecialized assets being combined by management in order for (systemic) innovation[27] to proceed. Managers do not always succeed in doing so, sometimes because they do not sense the need or the opportunity, and sometimes because they do but they are unable to effectuate the integration. If the assets cannot be procured externally, they will need to be built internally.

The ability of management to identify needs and opportunities to 'invest' in cospecialized assets (through its own development or astute purchase) is fundamental to dynamic capabilities. Mere 'horse-trading' skills (which market agents possess) will not suffice to build sustainable competitive advantage, and decisions on when and how to invest—whether and when to build or buy cospecialized assets—will depend upon many factors, including transaction costs. In particular, it will depend on management's entrepreneurial capacities with respect to matching up and integrating relevant cospecialized assets.

It is apparent that cospecialization involves 'lock-in' and is a particular form of complementarity that exists when technologies and other assets need to be part of a tightly integrated system to achieve the performance that customers want. Business success in such circumstances requires the coordination of R&D investment and alliance activity. The manner and timing with which such coordination needs to be accomplished is important to success (Teece, 1986; Mitchell,

[23] Lippman and Rumelt's (2003a, 2003b) recent work on developing the microfoundations for resource-based theory is very complementary to my development of the microfoundations of dynamic capabilities. I acknowledge their efforts in modeling cospecialized and complementary assets. In particular, they use the concept of supermodularity to bring in the tools of cooperative game theory. The idea of supermodularity was introduced by Donald Topkins as a way to formalize complementarity, and is also used by economists such as Milgrom and Roberts (see, in particular, Milgrom and Roberts, 1990) and evolutionary game theorists to model (strategic) complementarities (for instance, in models of R&D spillovers).

[24] Complete cospecialization is a special case of economies of scope where not only are complementary assets more valuable in joint use than in separate use, but they may, in fact, have zero value in separate use and high value in joint use. Cospecialization may stem from economies of scope, but they could also stem from the revenue enhancement associated with producing a bundled or integrated solution for the customer.

[25] Even if they are cognizant, they do not have the bargaining power to take advantage of the situation.

[26] This was not because the companies feared holdup in the face of highly specific assets. Rather, it was because they actively denied the desirability of the diesel and fought its introduction at every step. GM was forced to create its own capabilities in locomotive manufacturing.

[27] For a discussion of systemic innovation, see Teece (1988, 2000).

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1991). Common ownership of the parts facilitates system-wide innovation and economic performance (Teece, 2000) and protects against opportunism (Williamson, 1975).

To summarize, entrepreneurs and managers can create special value by combining cospecialized assets inside the enterprise (Teece, 2007). This may require investments to create the necessary cospecialized technologies—as illustrated by Thomas Edison and the creation of electric power as a system. It is not uncommon in technology-based industries to find that certain technologies are worth more to some market participants than to others, based on the technology they already have, and their technology and product strategy.

Learning, knowledge management, and corporate governance

With intangible assets being critical to enterprise success, the governance and incentive structures designed to enable learning and the generation of new knowledge become salient. There are many types of learning—including experiential, vicarious, individual, and organizational—and a large literature that explores each type. Also 'sensing' requires learning about the environment and about new technological capabilities. R&D was seen as one way that the enterprise could promote such learning. However, in the context of the dynamic capability discussed in this section, the ability to integrate and combine assets including knowledge is a core skill (Kogut and Zander, 1992; Grant, 1996). The combination of know-how within the enterprise, and between the enterprise and organizations external to it (e.g., other enterprises, universities), is important.

Integrating know-how from outside as well as within the enterprise is especially important to success when 'systems' and 'networks' are present. Good incentive design and the creation of learning, knowledge-sharing, and knowledge-integrating procedures are likely to be critical to business performance, and a key (micro)foundation of dynamic capabilities (Nonaka and Takeuchi, 1995; Chesbrough, 2003). Of equal importance are monitoring and managing the 'leakage,' misappropriation, and misuse of know-how, trade secrets, and other intellectual property. Of course, tacit know-how is difficult to imitate and has a certain amount of 'natural' protection. However, much know-how does leak out. Innovating business enterprises with limited experience have been known to inadvertently compromise or lose their intellectual property rights. Failure to proactively monitor and protect know-how and intellectual property is common.

The outsourcing of production and the proliferation of joint development activities likewise create requirements that enterprises develop governance procedures to monitor the transfer of technology and intellectual property. Technology transfer activities, which hitherto took place inside the enterprise, increasingly take place across enterprise boundaries. The development of governance mechanisms to assist the flow of technology while protecting intellectual property rights from misappropriation and misuse are foundational to dynamic capabilities in many sectors today. Figure 3 summarizes the microfoundations of this third class of dynamic capability.

There are also several other 'governance' issues relevant to dynamic capabilities. At one level there are governance and business model issues associated with an enterprise's ability to achieve asset 'combinations' and reconfiguration. As noted earlier, there is a continuous need to modify product offerings, business models, enterprise boundaries, and organizational structures. Decentralized structures that facilitate near decomposability are likely to assist in achieving reconfiguration.

One class of governance issues relate to incentive alignment. The microfoundations of incentive issues are embedded in an understanding of agency and incentive design issues, also discussed earlier. Agency theory has long emphasized that the separation of ownership from control creates interest alignment problems, particularly around management compensation and the allocation of corporate perquisites. The abuse of discretion and the use of corporate assets for private purposes can occur absent appropriate accountability/oversight. These issues become more severe as an enterprise grows and the separation between ownership and management widens. Recent corporate governance scandals in the United States, Europe, and Japan indicate the need for continued vigilance. However, increasing the mix of independent and 'inside' directors will not necessarily ameliorate problems associated with strategic 'malfeasance.'

There are likely to be benefits associated with participation at the board level by individuals who can calibrate whether the top management team

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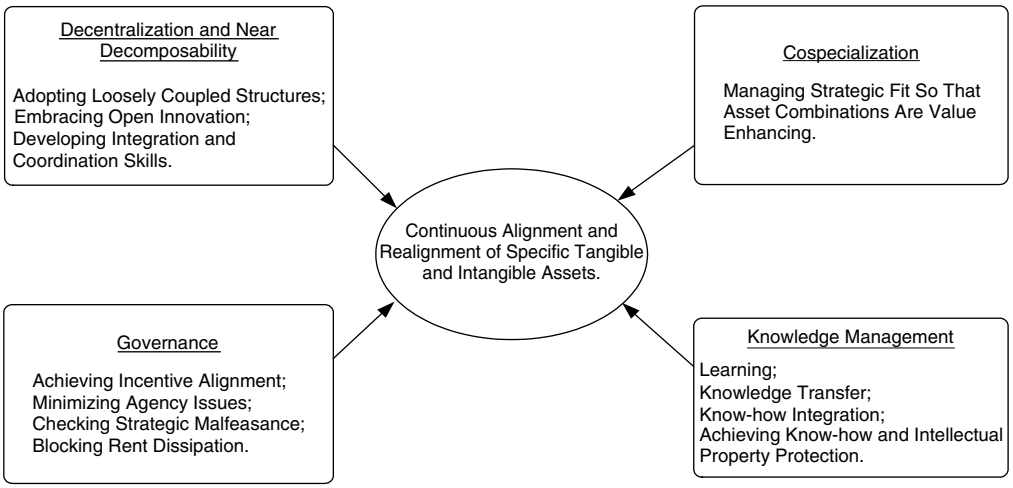

Figure 3. Combination, reconfiguration, and asset protection skills

is sufficiently 'dynamic.' The replacement of the CEO and other members of the top management team, if they demonstrate weak sensing, seizing, and reconfiguration capabilities (strategic 'malfeasance'), is important to effectuate. That is not to say that guarding against financial malfeasance is unimportant. It will always remain as an important corporate governance function; but its significance is likely to pale next to strategic 'malfeasance,' which is harder to detect and evaluate. The current wave of governance reforms in the United States—with its strong emphasis on accounting controls and systems integrity—may inadvertently lead to much bigger 'strategic' performance failures by management. Boards stacked with inexperienced 'independent' board members may not have the requisite talents to properly diagnose strategic 'malfeasance' and respond accordingly.

A related literature in economics has stressed how poorly designed incentives can produce tensions between the actions of employees and the actions needed to achieve profitable performance. Dysfunctional behavior, such as activity that generates influence costs, has received considerable attention (Teece, 2003). Also, through use of collective bargaining, employees in industries insulated from global competition have been able to appropriate economic surplus. Above-market wages—which characterized, and to some extent still characterize, certain enterprises in the auto, steel, and airline industries in the United States—are a case in point. These conditions can extend to managerial ranks as well. Restructuring may then require the judicious use of bankruptcy laws to rewrite uncompetitive supply contracts that are the product of unrealistic collective bargaining actions in an earlier period. The ability of some enterprises to craft work specifications, attract and retain more committed talent, design reward systems, develop corporate cultures, and blunt the formation of coalitions that extract quasi-rents through threatening to withhold participation, is an important managerial capacity.

The design and creation of mechanisms inside the enterprise to prevent the dissipation of rents by interest groups (both management and employees) would also appear to be very relevant to dynamic capabilities, but has not been high on the agenda of strategy researchers. One exception is Gottschalg and Zollo (2007), who point out that the capacity to continuously achieve incentive alignment is an important performance-enhancing (and rent-protecting) dynamic capability.

Many of the issues discussed here have, in the past, fallen under the rubric of human resource management; a closer connection of these issues to strategic management issues would appear to be warranted. The reason is that strategic management is focused not only on how to generate rent streams, but also on how to prevent them from being dissipated or captured by various entities or groups inside and outside the enterprise. For instance, the concepts of the 'appropriability regime' and 'isolating mechanisms' were developed by strategic management scholars to help explain how rents from innovation and other sources of superior performance can be protected and guarded from dissipation by competitors and

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others. However, the earlier focus on markets or 'external' competition did not address internal appropriation by interest groups.

DYNAMIC CAPABILITIES, 'ORCHESTRATION' SKILLS, AND COMPETITIVE ADVANTAGE

The general framework advanced here sees dynamic capabilities as the foundation of enterprise-level competitive advantage in regimes of rapid (technological) change. The framework indicates that the extent to which an enterprise develops and employs superior (nonimitable) dynamic capabilities will determine the nature and amount of intangible assets it will create and/or assemble and the level of economic profits it can earn (see Figure 4). Furthermore, the framework emphasizes that the past will impact current and future performance. However, there is much that management can do to simultaneously design processes and structures to support innovation while unshackling the enterprise from dysfunctional processes and structures designed for an earlier period.

In Teece and Pisano (1994) and Teece *et al.* (1997), we proposed three organizational and managerial processes—coordination/integrating, learning, and reconfiguring—as core elements of dynamic capabilities. These processes are a subset of the processes that support sensing, seizing, and managing threats. Together they might be thought of as asset 'orchestration' processes. A key strategic function of management is to find new value-enhancing combinations inside the enterprise, and between and amongst enterprises, and with supporting institutions external to the enterprise. Because many of the most valuable assets inside the firm are knowledge related and hence nontradable, the coordination and integration of such assets create value that cannot be replicated in a market. This establishes a distinctive role for managers in economic theory and in the economic system. Managers seek new combinations by aligning cospecialized assets (Teece, 2007). The need to sense and seize opportunities, as well as reconfigure when change occurs, requires the allocation, reallocation, combination, and recombination of resources and assets. These are the key strategic function of executives. Indeed, skills used to identify and exploit complementarities and manage cospecialization are scarce. Figuring out how to increase value from the use of the assets the enterprise owns involves knowing the fine-grained structure of the firm's asset base, and filling in the gaps necessary to provide superior customer solutions. Gap filling may involve building new assets, or acquisitions and strategic partnerships (Ettlie and Pavlou, 2006).

The dynamic capabilities framework recognizes that the business enterprise is shaped but not necessarily trapped by its past. Management can make big differences through investment choice and other decisions. Enterprises can even shape their ecosystem. In this sense, the framework is quite Chandlerian (Chandler, 1990a, 1990b). Managers really do have the potential to set technological and market trajectories, particularly early on in the development of a market (David, 1992). Indeed, the enterprise and its environment frequently coevolve. However, because of the assumed context—regimes of rapid technological change exposed to the full force of international competition—there is little room for big mistakes.

Hence, the dynamic capabilities framework is partially but not entirely in the spirit of evolutionary theorizing. The dynamic capabilities framework endeavors to capture the key variables and relationships that need to be 'manipulated' to create, protect, and leverage intangible assets so as to achieve superior enterprise performance and avoid the zero-profit trap. However, building and assembling tangible and intangible assets and effectuating change is seen as difficult. Long-run success is likely to require achieving necessary internal creative destruction, possibly involving spin-outs and spin-offs to help sustain superior performance. Decision biases must also be neutralized. In short, enterprises may be more like biological organisms than some economists, managers, and strategy scholars are willing to admit; but they are also more malleable than some organizational ecologists are willing to recognize.

The enterprise will need sensing, seizing, and transformational/reconfiguring capabilities to be simultaneously developed and applied for it to build and maintain competitive advantage. Simultaneity may not be necessary at the product level—indeed, Helfat and Peteraf (2003) distinguish between capability development and subsequent honing, grafting, and branding. Endeavoring to simultaneously achieve sensing, seizing, and reconfiguring at the individual product level could lead to chaos and lack of effectiveness, as routines and

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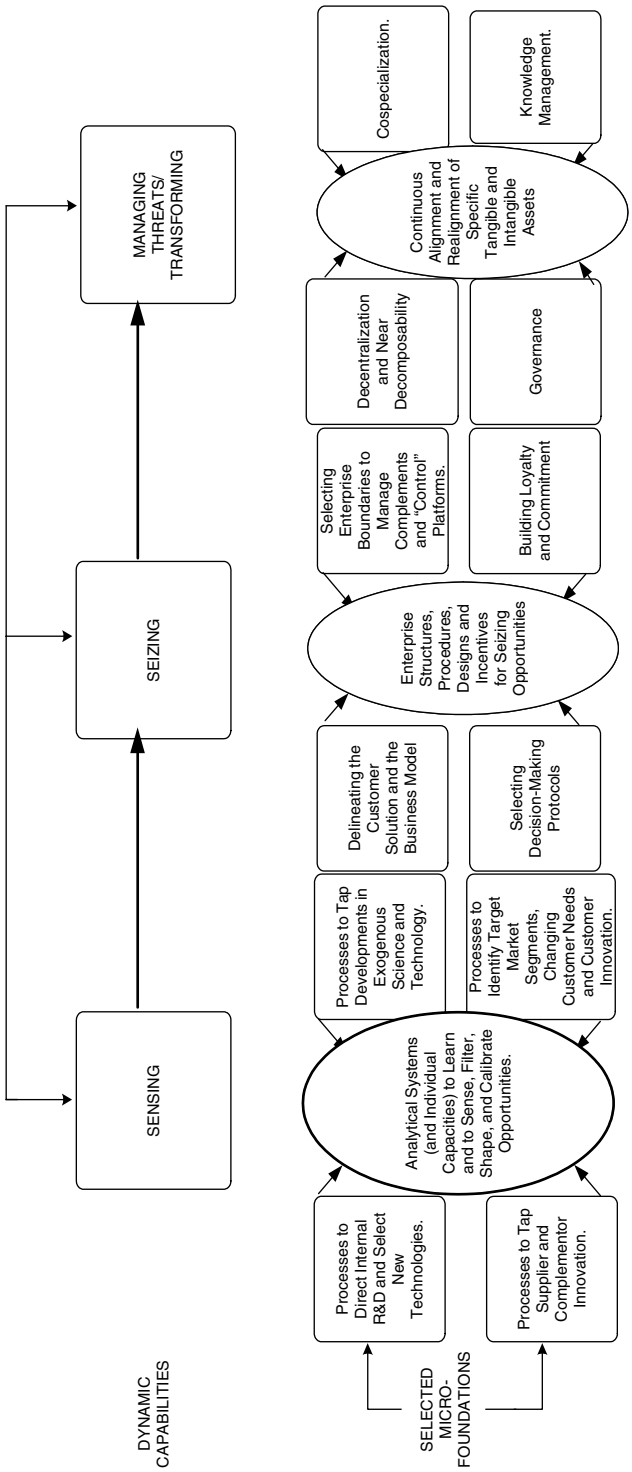

Figure 4. Foundations of dynamic capabilities and business performance

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rules in the organization would likely be in a continuous state of flux.

The first two capabilities recognized as fundamental—sensing and seizing—are related to but different from March's (1991, 1996, 2006) concepts of exploration and exploitation. March seems clear that both are necessary for adaptation, but he has recognized the tensions, if not incompatibilities, between the two. His argument in part is that incompatibilities flow from the fact that exploration and exploitation compete for resources and that the mindsets and organizational routines needed for one are different from the other, making simultaneous pursuit difficult, if not impossible (March, 1996: 280). While there is merit to each assumption, both need to be put into perspective. With respect to competition for resources, sensing does not necessarily involve large commitments of resources, at least not relative to seizing. Certain aspects, such as monitoring the environment, can be a low-cost activity. Early-stage exploratory research is also relatively inexpensive. Mansfield *et al.*'s (1971: Table 6.2) studies of new product development showed that the cost of early-stage research activities was a small percentage of the total new product development costs. For instance, the costs of pharmaceutical development typically far exceed those of pharmaceutical discovery. Also, with respect to the different mindsets and routines, while there are undoubtedly tensions, these can be relieved by having different organization units (or different parts of an organizational unit) specializing to some degree on sensing as compared to seizing. As Gupta, Smith, and Shalley (2006: 697) note: 'exploration or exploitation in one domain may coexist with high levels of exploration or exploitation in the other domain.' Of course, the outsourcing of manufacturing and other aspects of seizing reconciles the issues even more starkly, as the routines needed for proficient manufacturing then lie external to the firm.

The need for both exploration and exploitation is well accepted for adaptative systems, and is embedded in the literature on ambidexterity (e.g., O'Reilly and Tushman, 2007). This literature recognizes that both exploration and exploitation can be assisted by differentiated but partially or weakly integrated subunits (divisions, departments). Sensing activities need to be decentralized with the information rolling up to top management. Tight planning will be a part of seizing, but less so of sensing.

To summarize, an enterprise's ability to manage competitor threats and to reconfigure itself is dependent on its investment activity, which is in turn dependent on its ability to sense an opportunity. This aspect of dynamic capabilities indicates that the likelihood of achieving financial success depends on events and responses to them. Formally, let the probability of a high economic profits ranking for an enterprise, conditional on some extraordinary event E (e.g., an exogenous technological change that opens up the possibility of a new business opportunity) occurring,[28] be $P_r(\Pi|E)$. Then: $P_r(\Pi|E = P_r(\text{sense}|E) \times P_r(\text{seize}|E, \text{sense}) \times P_r(\text{manage threats/transform}|E, \text{sense, seize}) \times Pr((\Pi|E), \text{sense, seize, manage threats/transform})$.

As indicated throughout this paper and throughout earlier treatments by this author, it is also necessary to assess the issue of the 'sustainability' or nonimitability of both assets and capabilities. This in turn depends upon a number of factors summarized adequately by the twin concepts of 'isolating mechanism' and 'appropriability regimes.'[29] When the appropriability regime is 'tight' and the business enterprise's own isolating mechanisms are strong, differential performance can be sustained, at least for a time. Dynamic capabililties of course require the creation, integration, and commercialization of a continuous stream of innovation consistent with customer needs and technological opportunities.

Note that in the dynamic capabilities framework, enterprises must employ sensing, seizing, and reconfiguring mechanism to direct their financial resources consistent with marketplace needs and imperatives. However, as a matter of pure theory, enterprises need not continuously reinvent themselves. The need to reinvent depends on events, anticipated or otherwise. If the ecosystem in which the enterprise is embedded remains stable, the need to change can be modulated accordingly.[30] Indeed,

[28] Alternatively, one could assess the unconditional probability $P_r(\Pi)$ of earning such profits. $P_r(\Pi) = P_r(\Pi|E) + P_r(\Pi| \sim E)$ with $P_r(\Pi| \sim E)$ defined analogously to the definition of $P_r(\Pi|E)$ in the text. In competitive markets without dynamic capabilities, $P_r(\Pi| \sim E)$ is likely to be zero.

[29] Intellectual property protection, the tacit nature of know-how, and the inherent difficulty of the technology, all affect the ease of imitation. Another factor developed in this article is the unique coalignment of specific assets. Achieving such combinations may be difficult for imitators to effectuate.

[30] This assumes that the ecosystem remains attractive. If it does not, the enterprise will have to consider migrating to a different

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if an enterprise controls standards, or can somehow help stabilize its own environment, then it may not need to engage in the continuous and costly exploration of radical alternatives (March, 1991). Selecting suitable business models, making the right strategic investment decisions, and pursuing incremental innovation can keep an enterprise highly competitive for a decade or so (e.g., Boeing's decision to build the 747, which 30 years later is much improved and still competitive in some configurations on some routes) if the environment is stable. Excessive internal change for the sake of it can lead to internal chaos and performance failure.

RESOURCES/COMPETENCES DISTINGUISHED FROM DYNAMIC CAPABILITIES

The dynamic capabilities framework advances a neo-Schumpeterian theory of the firm and organizational decision making that is recognizable to those familiar with the behavioral theory of the firm, with evolutionary theorizing in economics, and with a Schumpeterian characterization of the innovation process. It also builds on what has come to be known as the resource-based approach. While the resource-based approach is inherently static, it is nevertheless relevant to dynamic capabilities. As noted by Teece *et al.*:

> the resource-based perspective also invites consideration of strategies for developing new capabilities. Indeed, if control over scarce resources is the source of economic profits, then it follows that such issues as skill acquisition and learning become fundamental strategic issues ... (Teece *et al.*, 1990a: 9)

Zott similarly recognizes that

> dynamic capabilities are more than a simple addition to resource based view since they manipulate the resources and capabilities that directly engender rents. (Zott, 2003: 120)

Collis (1994) and Winter (2003) also note that one element of dynamic capabilities is that they govern the rate of change of ordinary capabilities.[31] However, the notion advanced here is that, at least analytically, dynamic capabilities can be disaggregated into sensing, seizing, and transformational activities. Enterprises with good dynamic capabilities will have entrepreneurial management that is strategic in nature and achieves the value-enhancing orchestration of assets inside, between, and amongst enterprises and other institutions within the business ecosystem. Dynamic capability is a meta-competence that transcends operational competence. It enables firms not just to invent but also to innovate profitably (Teece, 1986, 2006).

The dynamic capabilities framework is integrative. Dosi, Nelson, and Winter (2000: 4) noted at one point the 'terminological flotilla' in the literature on organizational competences. However, perhaps there is now an emerging consensus that resources/competences map well into what historically we have thought of as the enterprise's operational capabilities, which help sustain technical fitness. Dynamic capabilities, by contrast, relate to high-level activities that link to management's ability to sense and then seize opportunities, navigate threats, and combine and reconfigure specialized and cospecialized assets to meet changing customer needs, and to sustain and amplify evolutionary fitness, thereby building long-run value for investors.

If an enterprise possesses resources/competences but lacks dynamic capabilities, it has a chance to make a competitive return (and possibly even a supra-competitive return) for a short period; but it cannot sustain supra-competitive returns for the long term except due to chance. It may earn Ricardian (quasi-)rents when demand increases for its output, but such quasi-rents will be competed away. It does not earn those Schumpeterian rents associated with 'new combinations' and subsequent recombination, or Kirznerian rents associated with bringing markets back into equilibrium. It might earn short-term Porterian rents associated with 'building defenses against competitive forces' (Porter, 1991: 22), but this is far too reactive for long-term success. Dynamically competitive enterprises don't just build defenses to competition; they help shape competition and marketplace outcomes through entrepreneurship, innovation, and

ecosystem, or reshaping the ecosystem itself. Both are very challenging tasks.

[31] As discussed here, dynamic capabilities certainly include this element, as well as several others.

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semi-continuous asset orchestration and business reconfiguration.

The archetypical enterprise with competences/resources but lacking dynamic capabilities will in equilibrium 'earn a living by producing and selling the same product, on the same scale and to the same customer population' (Winter, 2003: 992). Such an enterprise might even be good at invention, but it will likely fail to capitalize on its technological accomplishments. The operational/technical competences possessed might include basic ones such as order entry (to communicate what needs to be made/supplied), billings (to collect from customers), purchasing (to decide what inputs to buy and to then pay suppliers), financial controls (to restrict behavior and prevent theft), inventory controls (to minimize inventory costs) financial reporting (to access capital), marketing (to identify customers), and sales (to obtain orders). Management of these functions is commonly considered operations management.

Operations management is arguably at the foundation of basic management functions; but while knowledge of modern production systems took generations to develop, it is now widely diffused. The division of labor, uniform standards, the moving assembly line, measurement techniques for inspection, and control all of course had to be invented and they now constitute what we now think of as the (American) system of production.

Competitive advantage can in theory flow from superior operations, or what was referred to earlier as 'technical fitness.' Indeed, the Industrial Revolution saw significant differentials open up between craft systems and modern production systems, and these innovations led to an almost complete reordering of the industrial landscape. As Charles Babbage noted almost 200 years ago:

> [W]e shall notice, in the art of making even the most insignificant of [articles], processes calculated to excite our admiration by their simplicity, or to rivet our attention by their unlooked-for results. (Babbage, 1835: 3)

However, the postwar period has led to great progress in the understanding of how production systems work. Many useful techniques have been developed and improved. With developments in the field of management science and operations research, precise answers to narrow problems exist. Much is known about inventory management, scheduling, planning, quality control, and about managing isolated subsystems. The pursuit of 'benchmarking' and the adoption of 'best practices' has helped with the diffusion of discrete skills, protocols, and procedures. However, according to one of the field's pioneers, 'we have not learned very much about the relationships between these subsystems' (Buffa, 1982: 2). This is one place where dynamic capabilities come into play.

One implication is that special know-how—know-how that is difficult to obtain and apply—is needed to sense opportunities, execute plans, and configure and reconfigure assets and systems as necessary. Skill in putting things together to capture cospecialization benefits is important. Even with respect to operations management, it seems the pay-off today is in understanding how subsystems are related and interact together. Put differently, the understanding of the basic business functions that constitute business administration and operations management is widely diffused and hence well known, at least in advanced economies. The wide diffusion of knowledge with respect to such functions means that much can be outsourced or implemented inside any enterprise with relative facility. However, by running hard at this, an enterprise may manage only to stand still—what some refer to as the 'Red Queen' effect. Absent a broader overarching set of dynamic capabilities, a firm that is merely competent in operations will fail. However, understanding how to enhance performance of the enterprise through sensing future needs, making quality, timely, and unbiased investment decisions inside a well-designed business model, executing well on those decisions, effectuating productive combinations, promoting learning, reengineering systems that no longer work well, and implementing good governance remains enigmatic. The requisite managerial services that undergird dynamic capabilities cannot be outsourced. Understanding and implementing the processes and structures that undergird dynamic capabilities is enterprise specific, and requires intimate knowledge of both the enterprise and the ecosystem in which the enterprise cooperates and competes.

In this regard, a useful distinction can be made between entrepreneurs, managers, and administrators. Administrators are responsible for the day-to-day operations and the routine; they help ensure that the enterprise is technically fit, in the sense defined earlier. They are not expected to engage in entrepreneurial activities; e.g., they are not relied

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on to sense new business opportunities. Nor are they typically expected to discover the need for and to design new enterprise-wide operating routines, as this constitutes evolutionary fitness. The distinctions made earlier are implicitly recognized by Porter (1996) when he claims that operational effectiveness is not strategy. He recognizes that both operational effectiveness and strategy are essential to superior performance, but notes:

> The quest for productivity, quality, and speed has spawned a remarkable number of management tools and techniques, total quality management benchmarking, time-based competition, outsourcing, partnering, reengineering and change management. Although the resulting operational improvements have been dramatic, many companies have been frustrated by their inability to translate gains into sustainable profitability. And bit-by-bit, almost imperceptibly, management tools have taken the place of strategy. As managers push to improve on all fronts, they move farther away from viable competitive positions (Porter, 1996: 61).

Yet it is perhaps an overstatement to say that 'operations management' tools and procedures cannot be the basis of competitive advantage, or work against it. If there is a significant, tacit, non-inimitable component of an enterprise's superior operational competence, it has the potential for a time to support superior performance (it will, in fact, generate Ricardian rents).[32] Nevertheless, superior operational efficiency, while valuable, is not a dynamic capability.

CONCLUSION

For open economies exposed to rapid technological change, the dynamic capabilities framework highlights organizational and (strategic) managerial competences that can enable an enterprise to achieve competitive advantage, and then semi-continuously morph so as to maintain it. The framework integrates and synthesizes concepts and research findings from the field of strategic management, from business history, industrial economics, law and economics, the organizational sciences, innovation studies, and elsewhere.

Implicit in the dynamic capabilities framework is a recognition that relatively open regimes of free trade and investment, global dispersion in the sources of new knowledge, and the multi-invention or systemic character of such innovation have 'upped the ante' for modern management. Improving quality, controlling costs, lowering inventories, and adopting best practices ('technical fitness') will no longer suffice for long-run competitive success. Nor do traditional scale economies in production always have the differentiating power they may once have had. More than scale and scope advantage are needed. Success requires the creation of new products and processes and the implementation of new organizational forms and business models, driven by an intensely entrepreneurial genre of management constantly honing the evolutionary and entrepreneurial fitness of the enterprise. Entrepreneurial managers can sense and even help shape the future, unshackle the enterprise from the past, and stay ahead by augmenting knowledge assets, protecting them with intellectual property rights, establishing new value-enhancing asset combinations, and transforming organizational and, if necessary, regulatory and institutional structures. Dynamic capabilities reside in large measure with the enterprise's top management team, but are impacted by the organizational processes, systems, and structures that the enterprise has created to manage its business in the past.

Maintaining dynamic capabilities thus requires entrepreneurial management. The entrepreneurial management in question is different but related to other managerial activity. Entrepreneurship is about sensing and understanding opportunities, getting things started, and finding new and better ways of putting things together. It is about creatively coordinating the assembly of disparate and usually cospecialized elements, getting 'approvals' for nonroutine activities, and sensing business opportunities. Entrepreneurial management has little to do with analyzing and optimizing. It is more about sensing and seizing—figuring out the next big opportunity and how to address it.

We have come to associate the entrepreneur with the individual who starts a new business providing a new or improved product or service. Such action is clearly entrepreneurial, but the entrepreneurial management function embedded in dynamic capabilities is not confined to startup activities and to individual actors. It is a new hybrid: entrepreneurial managerial capitalism. It involves recognizing problems and trends,

[32] Wal-Mart and Dell Inc. have both used differentiated business models to anchor their competitive advantages.)

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directing (and redirecting) resources, and reshaping organizational structures and systems so that they create and address technological opportunities while staying in alignment with customer needs. The implicit thesis advanced here is that in both large and small enterprises entrepreneurial managerial capitalism must reign supreme for enterprises to sustain financial success. Nor is entrepreneurial management merely 'intrapreneurship,' as there is a large role for the entrepreneurial manager in external activities, including shaping the ecosystem.

As discussed, there are obvious tensions and interrelationships between and amongst the three classes of capabilities identified. The managerial skills needed to sense are quite different from those needed to seize and those needed to reconfigure. All functions have a significant 'entrepreneurial' and 'right brain' component. Successful enterprises must build and utilize all three classes of capabilities and employ them, often simultaneously. Since all three classes are unlikely to be found in individual managers, they must be somewhere represented in top management, and the principal executive officer must succeed in getting top management to operate as a team. Of course, if the principal executive officer has depth in all three classes of capabilities, the organization has a better chance of success.

The dynamic capabilities framework goes beyond traditional approaches to understanding competitive advantage in that it not only emphasizes the traits and processes needed to achieve good positioning in a favorable ecosystem, but it also endeavors to explicate new strategic considerations and the decision-making disciplines needed to ensure that opportunities, once sensed, can be seized; and how the business can be reconfigured when the market and/or the technology inevitably is transformed once again. In this sense, dynamic capabilities aspire to be a relatively parsimonious framework for explaining an extremely seminal and complicated issue: how a business enterprise and its management can first spot the opportunity to earn economic profits, make the decisions and institute the disciplines to execute on that opportunity, and then stay agile so as to continuously refresh the foundations of its early success, thereby generating economic surpluses over time. If the framework has succeeded in some small measure, then we have the beginnings of a general theory of strategic management in an open economy with innovation, outsourcing, and offshoring.

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