Abstract—This conceptual paper examines the impacts of technological discontinuities from a competence perspective. It proposes a composite model of positive and negative effects on innovation competencies, illustrated with examples of information technology innovation. It concludes that management strategies may be enacted to position a firm to mitigate many effects of disruptive innovation.

Index Terms—Management, technological innovation, organizational capabilities, liability of newness.

I. INTRODUCTION

I t is over two decades since Tushman & Anderson’s seminal work on the competence impacts of discontinuities [49], yet the role of competencies in innovation still attracts attention and raises questions [14], [24].

Tushman & Anderson argue that technological discontinuities enhance or destroy competencies. Competence-enhancing discontinuities are initiated by history-constrained existing firms while competence-destroying discontinuities are initiated by new firms. They conclude that “while liabilities of newness plague new firms confronting competence-enhancing breakthroughs, liabilities of age and tradition constrain existing, successful firms in the face of competence-destroying discontinuities” (pp45-46).

This view is consistent with March [31] who argues that exploration can impede exploitation, and vice versa. March also argues that both exploitation (refinement of existing capabilities) and exploration (innovation of new possibilities) are essential for organizations to survive and thrive.

However, [46] and [13] argue that the evidence supporting [49]’s view is equivocal. Not all incumbents fail in the face of technological discontinuities. Indeed, some seem to prosper.

This raises two central questions. What are the impacts of technological discontinuities on organizational competencies and the mechanisms whereby they have effect? Furthermore, what can be done to mitigate these effects?

To answer these questions, the paper draws on recent information technology (IT) project performance research from a competence perspective and applies it to the broader context of technological innovation. It suggests that a more complex set of interactions are at play in innovation processes and predicts greater variability in innovation effects and outcomes than that argued by Tushman & Anderson [49]. It also explains why [49]’s competence impacts on incumbents versus new firms may not be inevitable.

As Markides argues [32], “It is only when the topic of disruptive innovation is broken down into … finer categories that progress can be made” (p19). This conceptual paper aims to extend the knowledge base on the role of competencies in technological innovation. Section II outlines the contributing literature, while Section III presents the central arguments before conclusions are drawn in Section IV.

II. THEORETICAL BACKGROUND

A. Technological Discontinuities

Tushman & Anderson describe a technological discontinuity as a punctuation in the incremental progression of an established product or process by a technological advance “so significant that no increase in scale, efficiency, or design can make older technologies competitive with the new technology” [49] (p441). These discontinuities are categorized as competence-destroying or competence-enhancing because of their effects on the organizational competence stocks and competence accumulation processes for existing technologies. Competence-destroying discontinuities are so different from previously dominant technologies that the skills and knowledge required represent a fundamental shift. By contrast, competence-enhancing discontinuities are “order-of-magnitude improvements” in products or processes that build on existing knowledge and skills.

Tushman & Anderson [49] model technology innovation as a process of punctuated equilibrium – an evolutionary cycle of periods of incremental change punctuated by technological discontinuities that trigger a period of turmoil which culminates in a new dominant design ahead of another period of incremental competence-enhancing improvement.

Curiously, Tushman & Anderson [49] ignore less than “order-of-magnitude” incremental improvements in product or process in this model of innovation. That is, continuous improvements within the set of established competencies (what March [31] calls exploitation or refinement of existing competencies). Logically, technological innovation involves both continuous and discontinuous advances with respect to dominant designs and their underlying competencies, spanning small refinements of existing designs to disruptive, paradigmatic shifts in products, services and/or processes.

Why are competencies of interest in innovation research?

B. Organizational Competencies

According to the resource-based view of the firm, firm
performance is a function of internal resources, which are heterogeneously distributed across firms. Firm idiosyncrasies in accumulating and using differentiated resources drive superior firm performance and competitive advantage [7]. Rent-generating firm-specific resources are characterized as valuable, rare, non-tradable, inimitable, non-substitutable, causally ambiguous, socially complex, and having high organizational support [8], [17].

The competence-based perspective extends this view by emphasizing building and accumulating resources better and faster than competitors [39]. Competencies are intangible resources that comprise an intricate mix of knowledge, skills, routines and values. On this basis, competences in deploying, utilizing and managing change in technologies important to the business are critical to firm performance and survival.

A firm is modeled as a learning organization that builds and deploys advantageous, firm-specific competencies and applies them to achieve superior levels of performance [20]. A firm’s comparative effectiveness in developing and deploying competencies determines its marketplace success. Its ability to engage in technological innovation and respond effectively to innovations by other firms is a function of its accumulated innovation competencies and learning processes. Furthermore, its ability to adapt and innovate in identifying, building and leveraging new competencies is a competency in itself, called a ‘dynamic capability’ [45].

C. Organizational Learning

Organizational learning is described in the literature as the main generative mechanism of firm-specific organizational competencies. Competencies are developed through learning from experience, or ‘learning by doing’ [29]. Competencies are a “messy accumulation of learning” [20] (p12). Organizational competencies are developed and institutionalized in the operating routines, practices and values of organizations in a way that outlives the presence of specific individual members [35]. Routines that lead to favorable outcomes become institutionalized in organizations as competencies, which are adapted over time in response to further experiential learning. Firms can also deliberately build competencies through management practices [20], [34], [40].

Learning improves the ‘intelligence’ of the organization and, thus, its performance. In this sense, the ability to learn from experience is a critical competency, requiring a deliberate investment [12].

According to Argyris & Schön, learning takes two forms [3]. One is continuous with respect to existing organizational competencies (termed ‘single-loop learning’). The other is discontinuous, resulting in fundamentally different organizational rules, values, norms, structures and routines (called ‘double-loop learning’). Tushman & Anderson’s [49] “order-of-magnitude” improvement (competence-enhancing) effect of discontinuous innovation for incumbents would be positioned at the upper extremity of Argyris & Schön’s [3] single-loop learning dimension.

D. Liabilities of Incumbency and Newness

However, as implied by Tushman & Anderson’s [49] competence-destroying innovations, the literature reports that learning and competence development are neither certain nor cumulative. Barrier conditions may arise in the organizational and technological contexts of innovation-related activity that can inhibit or block learning and competence development and/or make accumulated competencies redundant or obsolete in the face of changed or new circumstances. These conditions can disrupt technological innovation and adoption.

There have been few consolidated studies of learning and competency barriers in the literature. Recent exceptions include [4] and [5]. Extending the analysis of [5], and drawing on the terminology of [49], the literature on barrier conditions can be categorized into two main types: liabilities of incumbency and liabilities of newness.

Liabilities of incumbency (‘liabilities of age and tradition’ as termed by [49]) are barrier conditions that slow or block the incremental accumulation of competencies. These conditions are often associated with the entrenched practices of established firms. Their effect is continuous, permitting various levels of flow like a water tap whose valve is progressively closed to restrict or fully interrupt the flow. In contrast, liabilities of newness are barrier conditions that make existing competencies redundant or obsolete, creating a propensity to fail. These conditions are often associated with the unfamiliar landscape of new or changed circumstances. Their effect is discontinuous, requiring different competencies to those needed for the previous situation or technology. Examples of each type follow.

Two types of liabilities of incumbency are found in the literature. The first comprises barrier conditions that can impede organizational learning and competence development. Examples include time compression diseconomies and asset mass inefficiencies [17]; absorptive capacity [11]; learning disincentives, certain organizational designs [30]; and low aspiration levels [50].

The second type of liabilities of incumbency comprises barrier conditions that can block organizational learning and competence development. Examples include tacitness [38]; organizational inertia [22]; competency traps [29]; a need for unlearning [36]; interconnectedness [17]; causal ambiguity [42]; learning myopia and focus diversion [31]; core rigidities [28]; complexity and embeddedness [9]; ‘stickiness’ [44]; unjustified theories-in-use [2]; managerial cognition [47]; and certain characteristics of projects [15], [27], [28].

Together, liabilities of incumbency slow or block learning and competence development, refreshing a firm’s likelihood to underperform.

Liabilities of newness are barrier conditions that can negate the value of existing organizational competencies and/or make them obsolete. Examples include newness [22], [43]; technological discontinuities [10]; ‘architectural’ innovations [25]; radical management methods such as tabula rasa

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1 The notion of competence is complex, described by many different terms and definitions in the literature. Descriptors include capability, distinctive competence, core competence, strategic asset and invisible asset. In the interests of parsimony, competence is used in this paper.
business process reengineering [21]; staff loss through turnover, downsizing or outsourcing [18], [30] [41]; organizational forgetting [16]; and asset erosion [17].

Individually and together, these organizational learning and competence development barriers can significantly diminish the ability of a firm to innovate or respond effectively to innovations by other firms. They can offset positive learning effects and devalue or destroy the accumulated competencies necessary for competitive success and firm survival.

E. Composite Effect of Liabilities on Competencies

Finally, recent research on IT projects posits a competence-based theory of project performance as the contested outcome of the generative and regressive drivers of organizational competence accumulation [5], [6]. Drawing on the literature outlined above, the theory models learning as a driver of positive performance through its generative effects on organizational competencies, and liabilities of incumbency and newness as drivers of negative performance through their regressive barrier effects on learning and competencies. Project performance is the contested outcome of the two opposite effects on the organizational competencies available to the project. This view is posited as an alternative to extant factor- and process-based explanations of observed high performance variance and failure rates in IT projects.

In the next section, it is argued that this model can be generalized to innovation performance. That is, to a firm’s ability to innovate and respond to innovations from its external environment.

III. COMPETENCE-BASED INNOVATION

This section now addresses the two motivating questions.

A. An Etiology of Innovation Competencies

In response to the first question (What are the impacts of technological discontinuities on organizational competencies and the mechanisms whereby they have effect?), current research suggests a broader, more complex set of interactions than those posited by [49].

Based on the literature outlined above, four critical drivers of innovation are mapped in Figure 1 and their interaction effects on innovation competencies are shown in Figure 2.

A firm’s internal innovation competencies are shaped by the four effects in Figure 1. Existing competencies are enhanced through continuous single-loop experiential learning, while new competencies are built through discontinuous double-loop learning processes. The joint effect is cumulative on the firm’s stocks of innovation competencies.

However, competence accumulation through organizational learning processes is neither certain nor guaranteed. Barrier conditions may arise in the organizational and technological contexts of the firm’s activities that can inhibit or block learning and competence development (liabilities of incumbency), or make accumulated competencies redundant or obsolete in the face of technological discontinuities and new organizational challenges (liabilities of newness).

![Fig. 1. Innovation competency drivers. A competence-based view of technological innovation recognizes positive learning effects on innovation competencies as well as barriers to learning and competence development (negative effects). Also, innovation may have an incremental (continuous) change effect on existing organizational competencies or it may fundamentally change the competencies that are used or required to operate and compete effectively (discontinuous effect).](image)

A firm’s ability to innovate effectively (i.e., its innovation performance) is a function of the organizational competencies applied to its innovation activities. These competencies are shaped by two opposing effects. Learning drives competence development and, therefore, the ability to innovate effectively. However, learning and competency barrier conditions diminish or negate existing competencies, reducing the firm’s ability to innovate effectively. A firm’s innovation competency is the contested outcome of the two opposite effects. These relationships are shown in Figure 2.

This dynamic model permits great variation in innovation performance outcomes, both in terms of the frequency and magnitude variance of innovation successes (and failures).

![Fig. 2. Innovation competencies model. The competencies available to an organization to engage in innovation activities are the contested outcome of the effects of positive learning drivers (single- and double-loop learning) and barrier conditions that impede accumulation (liabilities of incumbency) or negate the value (liabilities of newness) of relevant competencies.](image)
needed for future projects.

On this basis, even when competencies are developed in the current technologies during a project, it is likely that they are obsolete by the time the next project starts. Different hardware platforms and software tools may be required; the successful project manager is promoted and never manages another project; the project team changes; contractors leave; business sponsors and representatives come and go; and different challenges are introduced by the application context of the innovation. Similarly, changes in organizational directions, priorities, structures, processes and executives can set back cumulative learning and negate the value of accumulated competencies, reducing its stocks and ability to perform well.

This model differs markedly to that of Tushman & Anderson [49], which assumes a default state of evolutionary enhancement periodically punctuated by competence-destroying discontinuities. In contrast, the model presented here is one of constant interaction between drivers that enhance existing competencies and drivers that destroy them by making them redundant or obsolete. The resultant outcome on innovation competencies is a composite net effect.

This finer grained representation of competence-based innovation can explain the variation reported in the literature from Tushman & Anderson’s hypotheses (e.g., [13] and [46]). Path dependence may predispose incumbents to enhancing their operational competencies, but deliberate managerial action can also open up options for exploration.

B. Smoothing out Discontinuities

How can these composite effects be managed and the liabilities of incumbency and newness mitigated to enable the present to be exploited and the future explored? O’Reilly & Tushman [37] suggest a structural solution, the ambidextrous organization, which separates exploitation and exploration into different business units. This is consistent with [48], who show that operational competencies are different to reshaping competencies. Functional separation of exploitation and exploration enables each to develop within its own distinctive environment without cross-contamination. Another solution proposes employing multiple complementary organizational mechanisms [26].

Extending these views, the implication of Figure 2 is that the adverse effects of discontinuities can be mitigated by the firm positioning itself as much as possible within the learning part of the model. This requires a deliberate investment in dynamic capabilities for building operational (exploitation) and reshaping (exploration) competencies that are relevant to the firm’s business model, strategies and competitive position. Dynamic capabilities are a firm’s capacity to “purposefully create, extend, or modify its resource base” in response to changing needs [23] (p1). Building an ability to develop relevant competencies (a meta-competency) may be more enduring and less susceptible to technological disruption than competencies that are core to a firm for only a period of time.

Taking IT innovation again as an example, in the case of operational competencies, it is difficult, for a firm whose main business is not IT to build competencies in fleeting systems technologies for periodic, one-off developments. It would be more effective to focus on incrementally developing competencies in managing IT service delivery and outsource other technical needs to firms that already have or are better able to build the required technical skills. This strategy mitigates the firm’s exposure to technological discontinuities.

Similarly, in the case of exploration competencies, the same firm, for example, could invest in building competencies in brokering technical services from multiple specialist providers with a reputation for effective innovative solutions. This would incrementally build on its operational IT service delivery management competencies and provide the firm with access to technological innovations with substantial buffering from disruptive technological discontinuities.

Deliberate investment in this way requires managerial commitment as well as supporting and enabling structures, processes, practices and values to accumulate relevant core competencies as the organization adapts over time.

These strategies enable the firm to adopt a continuous learning mode in exploitation and exploration competencies, by building on their core operational competencies, thereby mitigating many of the risks and threats of disruptive liability conditions. Of course, there will be limits to any one learning trajectory. Technological and organizational discontinuities will still arise and impact the firm. However, an organizational commitment to innovation learning can buffer many of the effects of discontinuity through agile transitioning to new learning curves as they become necessary, smoothing out and cushioning the disruptive effects of the discontinuities.

IV. CONCLUSION

Managing disruptive technological innovation is a ongoing challenge for research and practice. Firms can live or die from discontinuous technological change. It is an issue for all.

The central contribution and proposition of this paper is that the effects of technological change may not be deterministic for established or new firms. Management strategies may be enacted to influence the positioning of the firm to mitigate disruptive change. The critical issue is to understand the drivers of exploitation and exploration competencies so that firm-specific situational strategies can be formulated and applied to maximize and capture the benefits of generative learning and minimize and contain the regressive effects of competence barriers. Positioning strategies that capitalize on opportunities for continuous learning and development may offer great potential for smoothing innovation discontinuities.

REFERENCES
