

**PATH CREATION
AS A PROCESS OF MINDFUL DEVIATION***

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Abstract

Entrepreneurs are embedded in structures from which they attempt to depart. It is to explicate this notion of agency that we offer path creation as a concept that lies in contrast to path dependence. Path dependence celebrates the role of chance historical events in shaping the flow of future events. Such a process perspective takes an outsider's view to the genesis of novelty. In contrast, path creators are boundary spanners who disregard myopic pressures from existing relevance structures by making mindful deviations with objects to create new futures. Time is a critical element in this process. Specifically, path creators negotiate the time required for their initiatives to mature and succeed. In doing so, they harness the dynamic efficiencies implicit in adopting a perspective that views the emergence of novelty ex-vizu of a point in time.

Think different

Slogan for Apple's iMac advertisement campaign.

Panasonic - Just slightly ahead of our time

Slogan for Panasonic advertisement campaign.

We live in an era of continual change. We are bombarded by new products and technologies some of which have the potential to fundamentally change our lives. It is not surprising, therefore, that many people are becoming increasingly interested in the genesis of novelty.

One perspective acknowledges the historical antecedents of novelty. Our present and future choices are conditioned by the choices that we have made in the past. Novelty, from this perspective, is not a negation of the past, but its elaboration and extension in specific directions depending upon the particular sequence of unfolding events. Stated differently, the emergence of novelty is a path dependent phenomenon (David, 1985; Arthur, 1988).

The insight that novelty has historical antecedents is refreshing. It offers us a way of understanding the emergence of novelty in process terms rather than having to resort to functional

explanations. Moreover, it provides us a way of viewing social action as being temporally located and socially embedded.

Despite these strengths, however, a path dependence perspective has important implications for human agency that are problematic for a theory of entrepreneurship. Path dependence suggests that "temporally remote" events play a key role in the development of novelty and that these events only gain significance post hoc. Indeed, proponents of a path dependence perspective often celebrate historical accidents to explain the emergence of novelty. They relegate human agency to "choosing to go with a flow of events" that actors have little power to influence in real time.

Departing from path dependence we offer a contrasting perspective that we label as path creation. In our view, entrepreneurs meaningfully navigate a flow of events even as they constitute them. Rather than exist as passive observers within a stream of events we see entrepreneurs as knowledgeable agents with a capacity to reflect and act in ways other than those prescribed by existing social rules and taken-for-granted technological artifacts (Schutz 1973; Blumer 1969; Giddens, 1984). In our view, entrepreneurs attempt to shape paths in real time by setting in motion processes that actively shape emerging social practices and artifacts only some of which may result in the creation of a new technological field.¹

Path creation does not mean entrepreneurs can exercise unbounded strategic choice. Rather, entrepreneurs are embedded in structures that they jointly create and from which they mindfully depart. Mindfulness implies an ability to disembed from existing structures defining relevance and also an ability to mobilize a collective despite resistance and inertia that path creation efforts are likely to encounter. Indeed, entrepreneurship is a collective effort where paths are continually and progressively modified as new technological fields emerge.

Facets associated with path creation are implicit in several bodies of work. In the economics literature, for instance, path creation is implicit in notions of dynamic efficiency and dynamic equilibria (cf. Schumpeter, 1942; Hayek, 1948; Kirzner, 1992). Literature at a socio-psychological level offers the concept of enactment – of how humans literally “put things out there” (cf. Weick, 1979). Complementing this perspective are those offered by social constructivists who explore the social and cognitive processes involved in the creation and diffusion of new technologies (cf. Bijker, Hughes and Pinch, 1987). Additionally, the forecasting literature offers "scenario thinking" as a process where practitioners work backward to fulfill a projected future state (Porter, et al. 1991). Even in the population ecology literature, there is an appreciation of "quantum speciation", or in other words, how mutants create new ecological spaces to grow and prosper (cf. Astley, 1985; see Rao and Singh, this volume).

By stressing path creation we want to draw attention to “phenomena in the making” -- i.e. the temporal processes that underlie the constitution of phenomena.² Such a perspective assumes reciprocal interactions between economic, technical and institutional forces that constitute the technological artifacts and actors involved. Thus, social orders, institutional rules and artifacts are both medium and outcome of human endeavors (Giddens, 1984; Berger & Luckmann 1966).

We begin with a brief description of path dependence and why its articulation is problematic for conceptualizing issues around human agency. We then offer an overview of path creation in contrast to path dependence. To develop a deeper appreciation of path creation, we explore how entrepreneurs are embedded in day-to-day activities involving the production and consumption of objects that take on specific meanings. Path creation occurs as entrepreneurs disembed out of these activities in ways that mobilize rather than alienate constituents of a technological field. After explicating these processes, we explore implications of path creation for key issues such as learning and commitment.

PATH DEPENDENCE

The origins of the path dependence perspective can be traced to David's (1985) description of the evolution of letters on the typewriter keyboard. His description suggested that actors of the time chose to address the jamming of typewriter keys by employing the QWERTY layout. Over time, the original problem

disappeared with the adoption of the ball keyface mechanism and then with the use of personal computers. Yet we have continued using the QWERTY keyboard.

Path dependence as non-ergodic processes

David ascribed this "stickiness" to *technology inter-relatedness*, *economies of scale* and *quasi-irreversibility* of efforts.³ These three elements constitute the basic elements of what he termed as *QWERTYnomics*. Suggesting that our use of the QWERTY keyboard can only be explained by employing a historical perspective, he offered path dependence as a concept.

"A path dependent sequence of economic changes is one of which important influences upon the eventual outcome can be exerted by *temporally remote events*, including happenings dominated by *chance elements* rather than systematic forces. Stochastic processes like that do not converge automatically to a fixed point distribution of outcomes, and are called *non-ergodic*. In such circumstances, "*historical accidents*" can neither be ignored nor reality quarantined for the purpose of economic analysis; the *dynamic process itself takes on an essentially historical character*." (David, 1985: 332; Italix added).

More generally, path dependence alludes to a sequence of events constituting a self-reinforcing process that unfolds into one

of several potential states (see chapters by Bassanini & Dosi and by Ruttan in this volume for excellent descriptions of path dependence and its origins). The specific state that eventually obtains depends on the particular sequence of events that unfold.⁴ Those who propose path dependence suggest that phenomena are sensitive to small differences in the underlying sequence of events. Consequently, a steady accumulation of small differences can result in the technological field locking onto a trajectory.

We can gain an intuitive feel for processes underlying path dependence by considering "Polya Urn" dynamics (Arthur, 1994). The Polya Urn contains balls of different colors. The dynamics unfold from a simple replenishment rule -- the probability of adding a ball of one color equals its current proportion. With such a rule, a slight imbalance in the proportion of balls can result in the urn eventually containing balls of only one color.

Arthur (1996) suggested that many contemporary phenomena are driven by such "increasing returns" logic. Driven by network externality effects (Farell & Saloner, 1986; Katz & Shapiro, 1985), phenomena begin exhibiting Polya Urn type of dynamics. Small accidents are magnified as complex non-linear interactions between customers, producers and regulators at the boundaries of an object eventually result in the emergence of a dominant standard. Sunk costs, learning effects, coordination costs are all forces from the past or the present that can explain "lock-in" to a trajectory over time (Arthur, 1988). Only rarely do future

expectations about the performance of a new technological trajectory have the power to unlock.

More broadly, path dependence alludes to the stickiness associated with specific technological trajectories that economic, technical and institutional forces generate. We find an appreciation of these forces in many literature streams (see Hirsch and Gillespie, this volume). Many have directed our attention to organizational routines that guide behavior (cf. Cyert & March, 1963; Nelson & Winter, 1982). Others have explored how characteristics of economic systems depend on their institutional contexts (cf. North, 1990; Whitley, 1992; Karnøe, Kristensen, & Andersen, 1999). Other institutional theorists have explored how activities in economic and social systems are dependent upon institutionalized rules (cf. Powell & DiMaggio, 1991). In technology studies, path dependence is apparent in the concept of technological trajectories (cf. Dosi, 1982). In the organizational ecology field, imprinting effects may determine the evolution of organizations (Stinchcomb, 1965; Hannan and Freeman, 1977; Baum and Singh, 1994).

Path dependence has been usefully employed at different levels of analysis. For instance, it has been used to explain the emergence of regions such as silicon valley (cf. Saxanian, 1994; Kenney and Burg, this volume), the self-referential processes associated with the functioning of business systems (cf. Whitley, 1992), the development of technological trajectories as a field gains

momentum (cf. Dosi, 1982, Hughes, 1983), problems and paradoxes in punctuated organizational change (Sastry, 1997). These studies provide excellent accounts of how specific institutional orders emerge and become stabilized.

Controversy within the paradigm

As we can see, path dependence is a powerful perspective increasingly being used to explain the emergence of novelty. However, even as we acknowledge the benefits of adopting such a process perspective, there is an important controversy that has surfaced. The roots of this controversy can be traced to the origins of the path dependence perspective. Path dependence was articulated to counter Neo-classical economist's assumption of optimal choice. Specifically, proponents of the path dependence perspective suggested that historical accidents result in phenomena locking onto choices that perpetuate market inefficiencies. It is this challenge from the proponents of the path dependence perspective that Liebowitz and Margolis (1990) question.⁵

To develop a critique of the path dependence perspective and its claims about market inefficiencies, Liebowitz and Margolis made a distinction between “weak” and “strong” forms of path dependence. Weak forms of path dependence entail "durability" and "false regret" (a situation where information gained post hoc may suggest an earlier sub optimal choice). Strong forms entail "true regret" -- making sub-optimal choices with full information. While ceding path dependence because of durability and false

regret, Liebowitz and Margolis argue that it is true regret that needs to be demonstrated in order to show perpetuation of market inefficiencies. As Liebowitz and Margolis point out, it is practically impossible to demonstrate inefficiencies arising out of true regret.

No doubt there are merits to Liebowitz and Margolis' arguments. However, it is unfortunate that this debate has become mired in this controversy as the path dependence perspective has much to offer in terms of thinking about paths as process. Moreover, the polemics of the debate around market inefficiencies has obscured a more fundamental facet of entrepreneurship. Specifically, in their quest to develop new paths, entrepreneurs intentionally deviate from existing artifacts and processes despite the perceived inefficiencies that deviations may create.

PATH CREATION

The need to escape myopic selection pressures of markets by designing technological fields that are inefficient by today's standards was recognized by none other than Schumpeter (1942). As a part of his theorizing on the process of creative destruction, Schumpeter suggested that "any system designed to be efficient at a point in time will not be efficient over a point in time." Systems designed to be efficient in the present will be associated with "relevance structures" (Schutz, 1973) that are likely to discourage experimentation because of associated inefficiencies. Experimentation requires "time" for new ideas to be refined and

grow even as new institutional and market preference structures co-evolve (Van de Ven and Garud, 1993). Time, therefore, is an important part of Schumpeter's process of creative destruction.

Path creation as mindful deviation

Schumpeter's gales of creative destruction were articulated to offer insights about macro economic processes. These insights are easily transferable to generate insights about entrepreneurship as well. Specifically, entrepreneurs may intentionally deviate from existing artifacts and relevance structures fully aware that they may be creating inefficiencies in the present, but also aware that such steps are required to create new futures.

Such a process of mindful deviation lies at the heart of path creation. Because deviations can be threatening to existing orders, entrepreneurs exercise judgment as to the extent to which deviations may be tolerated in the present and may be worthwhile to create new future.⁶ Entrepreneurs recognize that the extent to which they deviate from existing objects, relevance spaces and the present need to be synchronized for path creation to occur. In sum, mindful deviation implies disembedding from the structures that embed entrepreneurs.⁷

Path dependence or path creation

A juxtaposition of path creation with path dependence may provide an intuition for our perspective. In path dependence the emergence of novelty is serendipitous. Events that set paths rolling can only be known post-hoc. Consequently, the role of

agency is relegated to one of entrepreneurs driving forward while watching the rear view mirror. Stated differently, although path dependence focuses on a sequence of specific micro-level events, it does not have an explicated theory of agency.

Path creation attempts to remedy this. Agency takes on greater importance by bringing into play not only the social and institutional processes that are at play in path dependence, but more importantly, the socio-cognitive processes of enactment that are involved in the creation of new states (Weick, 1979; Garud and Rappa, 1994). In sum, an understanding of path creation processes provides a way of understanding how entrepreneurs escape "lock-in."

Entrepreneurs set path creation processes in motion in real time. Specifically, they attempt to shape institutional social and technical facets of an emerging technological field.⁸ But, to the extent that they are unable to generate momentum with their own approaches, path creation requires an ability on the part of entrepreneurs to shift their emphasis to alternative approaches that may have greater promise. This ability to create and exercise options, we think, is crucial.

Entrepreneurs creating new paths are not necessarily driven by a search for optimality (see also Rosenberg, 1994:53). For those creating paths, "errors" are red herrings as there are no pre-existing universal benchmarks that can flag the outcomes of an exploratory act as mistakes. Instead, entrepreneurs creating paths

explore the creation of new dimensions of merit that, in time, may set in motion a sequence of events (Garud and Rappa, 1994).

Rather than "errors" and "mistakes", advocates of the path creation perspective may use terms such as "experimentation" and "exploration", wherein any action is a probe into the world even as it is being created (March, 1991a, Weick, 1999). As March (1971) suggests, we may need a "technology of foolishness" in order to make advances with technologies.

In such a conceptualization, what is of value becomes endogenized within an overall process of entrepreneurship. That is, criteria that establish value about facts and artifacts do not lie in a "market" that is an overall arbiter of what is good and bad, but, instead become endogenized as a pattern of stabilized relations within an emerging technological field. Thus, the diverse actor-groups involved, including producers, users and regulators, "create" their own set of practices and relevance structures⁹ that co-evolve with technological artifacts (Schutz, 1973). From this perspective, the question of whether markets are efficient or not becomes secondary to a more important question -- Where do specific product markets come from? (Kirzner 1992; Koppl and Langlois, 1994; Ventresca and Porac, 2000).

Epistemological and ontological differences

Differences between path dependence and path creation perspectives are striking because they represent different epistemologies and ontologies. Path dependence assigns too much

weight to history; it inadequately characterizes the fragility of any path as it is produced and reproduced through microlevel practices where social rules and artifacts are enacted (Giddens 1984). Those who view phenomena as being path dependent are "outsiders looking in" at the emergence of novelty. As outsiders, agents may more likely embrace a logic of consequentiality (March, 1994) anchored on present ways of evaluation. Using this benchmark, any deviation from present acceptable social practices are mistakes that most likely will not survive (Christensen, 1997). Those mistakes that survive are, therefore, seen from an outsiders' perspective as "chance events" whose significance can only be known in hindsight. Temporal myopia, then, leads to a perception of inter-temporal serendipity.

For, entrepreneurs attempting to create paths, the world is constantly in-the-making.¹⁰ Indeed, entrepreneurs creating new paths are more likely to embrace a logic of mindful deviation. Such logic involves spanning boundaries between structures of relevance. On the one hand, entrepreneurs are "insiders" possessing knowledge of a technological field and an appreciation of what to deviate from and the value of pursuing such a strategy. On the other, entrepreneurs are "outsiders" (Blumer 1969) evaluating how much they can deviate from existing relevance structures. And, because many deviations are perceived as threatening, entrepreneurs have to "buy" time with which and within which to protect and nurture new ideas and to create new

provinces of meanings. From this perspective, ideas are carefully evaluated on an ongoing bases and even those that are "abandoned" may play a role in shaping ideas that survive over time (Garud and Nayyar, 1994). Temporal elasticity is linked with inter-temporal acumen.

In sum, a shift from path dependence to path creation occurs as entrepreneurs endogenize objects, relevance structures and time. As objects, relevance structures, and time become strategic variables, there is a shift from conceptions of path dependence as ways of "describing our past worlds" to conceptions such as path creation as ways of "shaping our current states" to create new futures. Entrepreneurship involves an ability to exercise judgment and choice about time, relevance structures and objects *within which* entrepreneurs are embedded and *from which* they must deviate mindfully to create new paths.

ENTREPRENEURS AS EMBEDDED AGENTS

The extent to which human actions are embedded in existing structures lies at the heart of an age old debate on strategic choice. In the technology studies literature, there is a fairly widely held view that humans are embedded in a larger technological field they themselves have helped create. Technological fields represent ongoing patterns of relations between heterogeneous entities that include objects and actors (Callon, 1986).¹¹

Objects constituting these fields are the physical manifestations of human efforts to tame and shape nature. They

include both primary and complementary objects required to create a useable product (Teece, 1987). Moreover, it is appropriate to include human behaviors and organizational routines required to create and maintain links between these disparate network of objects so that they can work together seamlessly.

Different actors are involved in the creation and maintenance of a technological field. Each actor enacts a frame of reference comprising a set of beliefs, standards of evaluation, and behaviors (Bijker, 1987; Dougherty, 1992, Karnoe and Garud, 1998). Three stylized frames that play a role in technology development are frames on *production*, *use* and *governance*. For instance, frames on production may include beliefs about the future potential of a technological trajectory with respect to its form and function. Frames on use may consist of the multiple meanings that can be attributed to a technological artifact when in use. Governance frames may include the value of the technology trajectory to multiple stakeholders on the one hand and the effect of specific policy instruments and funding to shape the development of a technology on the other.

Different actors in a technological field enact their realities based on their frames. Depending upon their vantage point as regulators, users and producers, agents begin to identify and ascribe specific meanings to the objects constituting the technological field. Eventually, these meanings become deeply internalized within actors.

As they enact their realities, actors interact with one another to negotiate the relevance of objects and behaviors that constitute the technological field. A debate ensues between these actors that eventually becomes institutionalized in practices and meanings. These institutionalized practices and meanings, in turn, affect individual actors by shaping their frames and their actions. A technological field takes on shape and meaning as an outcome of these intersecting processes.¹²

These processes are reflective of a broader proposition on structuration (Giddens, 1979, 1984). That is, structure is both medium and outcome of action. Rules and resources, drawn upon by actors in their interactions are reconstituted through their interactions. An important implication is that objects do not possess any intrinsic meaning in themselves. Objects and their meaning are produced and reproduced in communities of practice (Blumer, 1969; Brown and Duguid, 1991).

Over time, as constituent elements of a technological field begin working with one another, they become "aligned" and begin reinforcing one another (Callon, 1992; Hughes, 1983; Molina, 1999). Meanings of objects constituting these fields emerge through a process of negotiation and provisionally stabilize (Bijker, Hughes and Pinch, 1987). Indeed, in our quest to find simplicity in all this complexity, these meanings and practices become taken-for-granted (Hughes, 1983). Entrepreneurs then

become embedded in self-reinforcing processes of a technological field that they themselves have helped generate.

Entrepreneurial challenges

This discussion provides a finer appreciation of the many challenges of entrepreneurship. For instance, an entrepreneur may become so deeply embedded in these technological fields that a vision of the future that is different from the present is difficult to muster. Embedded actors continue reproducing existing practices because they may avoid new tests (Weick, 1979:149). Or, the impulse to exploit what has already been created is so great that the impulse to explore and create new structures may reduce or disappear (March, 1991a). For these reasons, an actor may not be able to develop the generative impulse that is required to set path creation processes in motion.

Notwithstanding the difficulties associated with recognizing and creating new opportunities, they are just the first of a number of challenges. Deviations may disturb the status quo thereby setting in motion a co-evolutionary reaction from interdependent actors with heterogeneous preferences and frames (Callon, 1986; Law, 1992; Latour, 1987). Co-evolution occurs as two or more parts of a field evolve together, not perfectly, but with slippages across time and space. In doing so, the co-evolving parts may both enable and constrain each other through feedback that can be negative or positive. Feedback can also be non-linear in that a response is not directly proportional to the stimulus. Non-linear

feedback to deviations creates interactively complex systems where deviations can either de-amplify and dissipate or amplify and spin out of control (Masuch, 1985).

For instance, unfavorable responses from powerful threatened actors can generate negative feedback. Even without these negative feedback, generating momentum within a network of co-specialized objects is difficult enough. Indeed, the very competencies within a technological field can become entrepreneurial traps (Levitt and March, 1988; Leonard-Barton, 1992). To complicate matters, these changes are often attempted within a short time frame during which entrepreneurs are unable to develop their insights or explain them in appropriate ways to significant stakeholders (Dierickx and Cool, 1989). Moreover, negative dynamics are generated and stoked by the very behaviors of entrepreneurs (Weick, 1979). Specifically, those who can muster the enthusiasm and the mindset to depart from existing embedding structures may be so enthused by their act of insight that they begin pursuing it with a single minded purpose. In doing so, they are likely to disregard feedback that others may provide and thereby miss out on an opportunity to mobilize others.

Even if entrepreneurs are able to generate momentum around their ideas, the process may "spin out of control." A process may spin out of control as an interactively complex system generates unmanageable processes that drive the system to unanticipated and unacceptable end states (Masuch, 1985).¹³ Once

again representing a vicious cycle, Perrow (1984) has characterized the negative outcomes of such unanticipated, unmanageable processes as representing "normal" accidents.

In sum, the embeddedness of action generates several challenges for entrepreneurs. Not only do they have to disembed from embedding structures, they have to also overcome the resistance they may generate in the process. Moreover, they have to mobilize elements of the network in which they are embedded to further their efforts even while preventing the process from spinning out of control. It is no wonder that path creation processes are fraught with failure!

It is to address these challenges that we will probe deeper into path creation processes. Paraphrasing Pettigrew (1992), we will attempt to offer an understanding of entrepreneurship in a way that: (1) acknowledges the embeddedness of actions (2) explores temporal interconnections between processes, (3) provides a role in explanation for context and action, (4) is holistic rather than linear, and (5) links process analysis to the location and explanation of outcomes.

PATH CREATION PROCESSES

How might entrepreneurs overcome the constraining effects of the dimensions that potentially imprisons them?¹⁴ An answer, we suggest, lies in an ability to endogenize objects, relevance structures and time. Such an ability generates agency for

entrepreneurs in their being able to disembed from existing technological fields even as they shape emerging ones.

To develop this proposition and motivate our discussions, we will use a widely known story of path creation -- the development of Post-it[®] Notes -- for illustrative purposes. Most accounts of its development suggest that it was an "accident." In this sense, these are outsiders' accounts consistent with a path dependence perspective. However, an interview with an insider, Spence Silver (the scientist at 3M who first discovered the weak glue that is applied on Post-it[®] Notes), offers a glimpse of how such "accidents" are consistently cultivated and nurtured to create something of value.¹⁵

Mobilizing molecules

Reflecting on his experiences with the development of Post-it[®] Notes, Silver vehemently denied that his discovery was a "mistake that worked." Rather than a random act of discovery, Spence described his discovery as a cultivated breakthrough that occurred because he chose to deliberately deviate from existing ways of mixing molecules:

In the course of the exploration I tried an experiment with one of the monomers in which I wanted *to see what would happen if I put a lot of it into the reaction mixture*. Before we had used amounts that would correspond to conventional wisdom. The key to the Post-it adhesive was doing

this experiment. *If I had really seriously cracked the books and gone through the literature, I would have stopped. The literature was full of examples that said you can't do this.*

People like myself get excited about looking for new properties in materials. I find that very satisfying, to *perturb the structure slightly and just see what happens*. I have a hard time talking people into doing that -- people who are more highly trained. Its been my experience that people are reluctant just to *try, to experiment* -- just to see what will happen!" (From Nayak & Ketteringham, 1986: 57-58; Italix added)

His experimentation paid off as he created a substance that he thought looked beautiful under a microscope. This finding aroused his intellectual curiosity. This curiosity quickly led to an intuitive appreciation of the potential value of what he had stumbled upon. In his words, he had created "a solution looking for a problem" (From Lindhal, 1988:14)

Silver's act of insight is reminiscent of Pasteur's famous adage -- "Fortune favors the prepared mind." It was because of Silver's prior professional knowledge in monomers that he could carry out a systematic experiment. And, when he "stumbled" upon something different, he could appreciate its potential value.

As this description suggests, insights emerge by building upon past experiences, not by negating it (Schutz, 1973; Bijker, 1987). Indeed, in offering their perspectives on entrepreneurship, many have noted how continuity and change are somehow paradoxically associated. For instance, Schumpeter (1934) considered entrepreneurship as acts reconstituting existing resources to create new ones. Similarly, his contemporary and colleague, Usher (1954), argued that innovation is a cumulative synthesis of evolutionary ideas that lead to revolutionary outcomes.

Acknowledging the importance of continuity in the entrepreneurship process, and indeed recognizing its constraining effects, some have suggested the need to deframe (Dunbar, Garud and Raghuram, 1996). Deframing implies appreciating cognitive embeddedness in order to depart from existing "webs of significance" (Geertz, 1973) in mindful ways. In a similar vein, others suggest discrediting (Weick, 1979) and unlearning (Hedberg, 1981; Starbuck, 1996). Discrediting implies purposely reversing or breaking causal structures of associations -- as Weick suggests, "when you believe, you must disbelieve" (see Grove (1996) for an example of how he and those at Intel discredit). Unlearning implies a break from the past and consequently an ability to break away from the iron cage of history.

Silver's ability to simultaneously employ and disembed from his professional knowledge base was impressive enough. To

appreciate the true significance of Silver's story, however, we must appreciate the corporate context within which he was embedded. Silver was working at 3M Corporation, a firm that celebrated glues that stuck. As Nayak & Kettingham (1986:61) suggested in their write-up of the origins of Post-it[®] Notes, "In this atmosphere, imagining a piece of paper that eliminates the need for tapes is an almost unthinkable leap into the void." For many, a natural impulse in this firm would have been to look for glues that stuck while ignoring or actively rejecting glues that did not. The fact that Silver could perceive and create an opportunity inherent in an object that would have been alien to most at 3M suggests a remarkable ability to disembed from localized contexts of meaning.

Mobilizing minds

Such disembedding is only the first of many challenges associated with entrepreneurship. Most deviations are met with apathy at best and resistance at worst. Indeed, Silver and his colleagues encountered these impulses in equal measure despite 3M's institutionalized appreciation for innovation. Most 3M people said, "what can you do with a glue that does not glue?" Those in manufacturing showed more active resistance as is evident in this description:

What added to the difficulty was the natural resistance of people. The engineers in 3M's commercial tape division were accustomed to tape

-- which is sticky all over on one side and then gets packaged into rolls. To apply glue selectively to one side of the paper and to move the product from rolls to sheet, the engineers would have to invent at least two entirely unique machines" (From Nayak & Kettingham, 1986: 66; Itlix added)

Silver encountered similar resistance and indifference from those outside 3M. He and Walt Kern, an attorney at 3M, had to convince patent attorneys outside that 3M had really discovered something that was new and valuable. At that point in time, Post-it[®] Notes did not exist. Preferences had yet to evolve, institutionalized ways of using Post-it[®] Notes had yet to congeal and 3M's capabilities for producing Post-it[®] Notes were not even on the radar screen. In short, there was nothing that was real (Pinch, in this volume, describes a similar situation with the development of the synthesizer).

3M's patent application was rejected twice with the second one coming back stamped "THIS REJECTION IS FINAL" in capital letters. Silver remembers telling 3M's attorney "I know this is new. I've never seen anything like this before. We're just not convincing this examiner about what's going on."

This description of resistance and indifference to new ideas is typical of entrepreneurial processes. From our vantage point, Silver's deliberate experimental perturbation of molecular

structures in turn resulted in the perturbation of existing relevance structures. Such co-perturbations are likely to occur in any entrepreneurial context. Consequently, entrepreneurs often encounter apathy and resistance. What is important for the emergence of a path is how entrepreneurs deal with these forces.

Silver was undaunted by the resistance and indifference that he encountered. Describing himself as a "zealot at times in order to keep interest alive" (Nayak & Ketteringham, 1986:60) Silver went from "door to door" in his attempts to talk with anyone who would listen -- technical directors, other scientists, the tech-group he was part of. He hoped to enlist their help and support to develop something of value from the glue that did not glue. In short, Silver was trying to mobilize a collective to identify a "problem for his solution."

In writing about Silver's efforts, Nayak & Ketteringham (1986:56) highlight "Faced with an irrational commercial challenge, Spence Silver applied an unnatural irrationality to the Post-it adhesive." Indeed, Silver's efforts highlights a paradoxical quality that entrepreneurs possess. On the one hand, Silver was a "zealot" trying to keep an idea alive. On the other, he was ready to share his ideas with others, even modify them, as he went about seeking problems that complemented his solution. This persistence¹⁶ with flexibility is an important part of path creation. It offers another vantage point on mindfulness, one where "A fixed

view of the future is in the worst sense ahistorical" (Mitchell, 1940).

Those at 3M described Silver's flexibility with persistence as *tenacity*. Corporate Scientist Larry Clemens who was Silver's colleague pointed out, "Silver is the definition of tenacity. He got rejected on that adhesive many times, but he stuck to it. He really felt that people were missing an opportunity." Adding --"What have I learned from working with Silver? I learned tenacity pays off" (From Lindhal, 1988:17).

Boundary spanning Silver actively cultivated this paradoxical property by being a *boundary spanner*. He offered: "I've always enjoyed crossing boundaries. I think it's the most exciting part of the discovery process" (From Lindhal, 1988:16). This excitement was a recognition that any new idea has to be meaningfully "translated" for and with others.

Translation is a key proposition in a literature on actor network theory (cf. Callon, 1992, 1986; Law, 1992). Callon defines a successful process of translation as one that generates a "shared space."¹⁷ This shared space is generated by presenting an idea in ways that are understandable by others. Indeed, entrepreneurs may present the same idea in different ways to different constituencies at appropriate points in time.¹⁸ In doing so, entrepreneurs attempt to enroll others by strategically drawing upon others' past experiences and by evoking appropriate pictures

of possible futures (see Van Looy, Debakere, Bouwen, this volume, on the importance of boundary spanning).

Besides the creation of a shared space, translation also implies the transformation of the idea itself through interactions. Such transformation is required to overcome resistance and indifference. It also sets the bases for generating buy-in required to mobilize a critical mass around an idea.

In this regard, Silver was not just a skillful entrepreneur in the technical sense of the word as manifest in his ability to mobilize molecules, but a skillful social entrepreneur as well as manifest in his ability to mobilize minds. In highlighting the importance of social skills required of institutional entrepreneurship, Fligstein (1997:398) suggests: "Social skill is the ability to relate to the situation of the 'other.' This means that, wherever a given strategic actor has interests, he or she must take other people's interests into account if organizational fields are to come into existence and remain stable. Skilled social action revolves around finding and maintaining a collective identity of a set of social groups and the effort to shape and meet the interests of those groups."

This discussion offers us an opportunity to specify the nature of agency associated with entrepreneurship. Clearly, entrepreneurs cannot do what they choose in pursuing their narrow self-interests. Rather, entrepreneurship is a collective enterprise where a shared space is created and nurtured by members of a

community who derive different meanings from their involvement (see similar arguments in Hirsch & Lounsbury, 1997).

Besides an ability to translate, a boundary spanners role offers other benefits. For instance, a boundary spanning perspective offers entrepreneurs with an opportunity to look at their ideas dispassionately even as they remain steadfastly resolute about the overall potential of their ideas. This *tenacity* provides entrepreneurs an ability to present their ideas to others with conviction even while incorporating feedback generated to modify their ideas.

Indeed, a more accurate description of the process of creation would be to consider the process as a "bisociation of ideas" as boundary spanners connect. This is consistent with Usher (1954) and Koestler's (1964) description of the genesis of novelty as a process of cumulative synthesis. Extolling the virtues of boundary spanning as a catalyst for such cumulative synthesis, Silver offered:

I think it is the most exciting part of the discovery -- when you bring two very different areas together and find something completely new. I worked for a very long time on a project called the quartz crystal microbalance with surface chemist Morgan Tamsky and Bob Oliveira, who was a biochemist and knew a lot about immunology. *This was a real nifty synthesis of a bunch of*

different disciplines where we crossed a lot of boundaries. (From Lindhal, 1988:16; Italix added)

Generating momentum At 3M, path creation processes began gaining momentum when Silver was able to convince "the first of many champions," a fellow scientist by the name of Bob Oliveira, to join his quest. Silver and Bob set about plotting how they might "sell" the material to others. At one time, the weak glue was applied to a bulletin board on which small pieces of paper could be stuck. Apparently, this initiative received a luke-warm reaction from those at 3M.

In 1974, almost ten years from the discovery of the weak glue, another 3M scientist, Art Fry, became involved. To be sure, the weak glue molecules had further evolved. Yet the fundamental problem remained -- it was a glue that did not glue.

Silver had sought Fry's help to identify a problem for his solution. Fry's act of insight occurred during a choir rehearsal at his church. Constantly losing his mark in his song book, Fry had a flash of insight -- Silver's weak glue could be a solution to his problem. Fry thought he could apply the weak glue to pieces of paper that could be stuck in the song book as a temporarily permanent book mark.

For those unfamiliar with the entire history it might appear that the development of Post-it[®] Notes was a smooth and straight forward process subsequent to Fry's act of insight. However, Fry's act of insight was still just a beginning. Subsequent champions

involved in the development of Post-it[®] Notes encountered indifference and resistance from people within and outside 3M. The project could have failed at any time. Indeed, the entrepreneurial cycle involving disembedding, translation and mobilization of minds and molecules was repeated again and again.

These observations are consistent with Usher's (1954) observations on the genesis of novelty. Based on his study of hundred years of mechanical innovations, Usher suggested that "acts of insight" occur as entrepreneurs "set the stage", but they are invariably followed by a process of "critical revision." Critical revision is followed by a new cycle as entrepreneurs "perceive" other problems and opportunities. Indeed, in the process of critical revision, entrepreneurs may come to a realization that the original idea itself is not feasible and must be modified or abandoned. Consequently, a judgment of whether to persist or desist at different stages of the entrepreneurial journey is an integral part of path creation.

Co-evolution of minds and molecules In the Post-it[®] Notes case attempts at mobilizing minds led to the mobilization of molecules instead. As we mentioned, weak glue molecules had at first been applied to bulletin boards on which pieces of paper were stuck. Rather than think of the problem as one of selling sticky bulletin boards, Fry was able to disassociate the glue from the board, and instead, applied the glue directly to paper. What is

equally intriguing is that Silver, appreciating the value of Fry's act of insight, was flexible enough to throw away the bulletin board and apply his "solution" to a "problem" Fry had discovered. As one 3M employee commented, we don't kill ideas, *but we deflect them*" (From Peters and Waterman, 1982: 230).

The co-evolution of minds and molecules is a key proposition in the actor network theory literature (Callon, 1986; Latour, 1987; Kreiner and Tryggestad, 1997). Such a co-evolution of minds and molecules requires flexible minds and flexible objects. Flexible minds implies an ability to change structures of relevance in the process of mobilization and translation. It builds upon the value of generating "interpretive flexibility" (Bijker, Hughes and Pinch, 1987) where the same set of ideas are evaluated and used in different ways.

Flexibility with objects may be gained by "chunking" them (we use "chunking" as a term in a way that is complementary to "tuning" that Baum and Silverman use in their chapter in this volume). Chunking of objects offer several benefits to those attempting to set path creation processes in motion. For instance, entrepreneurs can partition technologies in meaningful ways. Entrepreneurs can exercise judgment as to how much of their deviations might be presented and communicated to key stakeholders such that they are not threatened by them but are galvanized instead. Indeed, chunking provides entrepreneurs with an opportunity to share different chunks with different people at

different points in time, and, in the process, shape emerging preferences of key stakeholders. As specific chunks are presented to different social groups, entrepreneurs generate feedback that can be incorporated to make appropriate adjustments to the objects that are being shaped. Indeed, as they experiment with different chunks, entrepreneurs can decide which chunks to keep and which ones to abandon.

In sum, by chunking objects, entrepreneurs are able to perturb the technological field even as it is being created. As a consequence, new landscapes emerge in the very act of "trying" something. Feedback that is generated from such a probe becomes the basis for making appropriate changes as new possibilities open up or close down.

As this description suggests, entrepreneurial ideas are modified many times, over time. Indeed, many ideas may be abandoned or shelved during the entrepreneurial journey. Entrepreneurs use their judgment on how much they should persist and when to "pull the plug" all the while learning from their "mistakes."

Such a process embraces a "real options" approach to the navigation of complex dynamic flow of events (Luehrman, 1998). Options value is realized because stepwise investments generate sequential outcomes that serve as a bases for deciding whether or not to continue, modify or abandon a course of action.

Entrepreneurs generate a set of compound options that are revealed with choices at each stage of a complex journey.

Indeed, these processes begin to address the probe of the field "spinning out of control." As we mentioned earlier, a system may spin out of control as the interactively complex system generates unmanageable processes that drive the system to unanticipated and unacceptable end states. By chunking technologies, an entrepreneur gains greater control over a potentially chaotic process. This happens because of their position at the center of an overall architecture that the entrepreneur orchestrates. Even as others gain access to some chunks, the entrepreneur can begin developing and deploying additional chunks.

Virtuous cycle Indeed, Silver continued to orchestrate the process by being at the center of an emerging technological field. Silver's "tenacity" and an opportunity to associate and bisociate at 3M led to the building up of a momentum as minds and molecules were mobilized. In Silver's words:

It was more like a *slow crescendo* of things, which is typical of the discovery process. Things build up and you *begin to see the options the discovery creates*. (From Lindhal, 1988:14; Italix added)

Among the many others who played key roles in the Post-it[®] Notes saga were Nicholson and Ramey from marketing. Nicholson and Ramey also experienced some of the same struggles

as people before them had encountered. To "translate" the idea, Nicholson and Ramey hit upon the idea of offering free samples to others to play with. Eventually, because of Nicholson and Ramey's efforts Lew Lehr, the CEO of the company, was enlisted. In turn, Lehr was successful in enlisting other CEOs. Reflecting on this process of translation where a glue that did not glue eventually was conceptualized as offering a key business opportunity, Fry commented,

There are so many hoops that a product idea has to jump through. It really takes a bunch of individuals to carry it through the process. It's not just a Spence Silver or an Art Fry. *It's a whole host of people*. It's a classic 3M tale. I couldn't have done what I did without Silver. And without me, his adhesive might have come to nothing. (From Lindhal, 1988:17; Italix added)

We can only imagine the number of times that molecules and minds were translated within and outside 3M before they all became co-aligned to structure a world where Post-it[®] Notes have become taken-for-granted. What is apparent in the attributions implicit in the accounts of those involved in the process is that the innovation rightly belonged to a number of people associated with a process that unfolded over a long duration of time. This is invariably the case with most acts of entrepreneurship (Braun & Macdonald, 1978; Latour, 1987). Consequently, it is important to

conceptualize human agency as a relational concept; one that recognizes entrepreneurship as a collective enterprise and as an outcome of processes that translate and mobilize heterogeneous elements to generate a technological field. Those attempting to create new paths have to realize that they are part of an emerging collective and that core ideas and objects will be modified as they progress from hand to hand and mind to mind. Eventually, what may emerge from these processes may be very different from what was initially conceptualized (see Porac, Rosa, Spanjol, and Saxon, this volume, for the emergence of a consensual system between many constituencies that led to features of an automobile as we use it today). In this sense, there are accidents, but these accidents are a series of cultivated breakthroughs waiting and planned to happen, each breakthrough setting the stage for another in an overall process of cumulative synthesis. In such a virtuous cycle, "normal" accidents have a positive connotation as compared to the negative connotation implicit in the use of the term by Perrow (1984) to describe a vicious cycle.

In sum, path creation, in the case of Post-it[®] Notes, involved the disembedding of an individual from localized structures of relevance and provinces of meaning, overcoming the inertia and momentum that he encountered, mobilizing others to work on an idea that was transformed over time, all the time being flexibly resolute with a vision of what might be possible. Returning to our earlier discussions on co-evolutionary processes,

Silver and his colleagues were successful in setting in motion a virtuous co-evolutionary process (Masuch, 1985). Not only were they successful in mobilizing the minds of people, but they were also successful in mobilizing the molecules that constitute Post-it[®] Notes.

Mobilizing time

We could stop here with our story of Post-it[®] Notes as a revelatory case for explicating our perspective on path creation as a process of mindful deviation. To do so however, would be to miss out on an opportunity to dwell upon an important facet of path creation that is implicit in the development of Post-it[®] Notes and one that is present in every entrepreneurial initiative -- the role of *time*.

Post-it[®] Notes did not emerge overnight -- it took about 12 years from Silver's first discovery before Post-it[®] Notes were mass manufactured! Some question how such a process could have taken so much time. Notwithstanding this debate, it is apparent that path creation as a process must be thought of as unfolding over time that is projected into the future and not just as a natural unfolding of historically conditioned events from the past.

Elucidating the importance of time as a resource underlying the unfolding of these co-evolutionary processes, Silver suggested:

...things don't happen all of a sudden. *It's a process.* You're in the process of doing experiments. You're getting analytical data, send-

ing samples off to different groups. These groups give you analytical feedback and you do some more experiments. *It all takes time.* (From Lindhal, 1988:15; Italix added)

Indeed, one theme that appears repeatedly in all accounts of the development of Post-it[®] Notes is the need for and an ability to marshal time as a resource. Here, it is easy to connect with Schumpeter's (1942) views on time as a resource with which and within which entrepreneurship flourishes. There are many others who have recognized the importance of time as a key resource for entrepreneurship including Francis Bacon (1625) who implicitly recognized the importance of time when he suggested in his essay titled *On Innovation*: "As the births of all living creatures are, at first, misshapen, so are all innovations..." Extending Bacon's metaphor, it takes time for a caterpillar to become butterfly and the transformation process is clearly not straight forward.

It is with this recognition of time as a resource that 3M has wisely chosen to institutionalize the importance of imagining the future in order to create it (Coyne, 1996). In many instances, managers are chided for having taken on too short a time frame. Such a focus on time as a resource is despite or because of 3M's status as a large corporation producing many products that have to meet the needs of the marketplace today. Perhaps, employees at 3M are intuitively aware of what March (1998) suggests -- long time frames are key for the exploration of ideas.

Time, timing and temporality These discussions have important implications for path creation. Specifically, those entrepreneurs anchored in today's business practices are less likely to gain the generative impulse to explore. We can gain additional insights by reversing the relationship between time and exploration. Specifically, any exploratory act requires an appropriate time frame within which and with which novelty emerges. Combining these two propositions, time frames and degrees of novelty must be matched. If too little time is slotted for the deviation, then, either it will be half done, or may not even be perceived as an interesting novelty to those involved. Too much time, in contrast, may result in the trivialization of the idea, or in a situation where those attempting to create a path are unable to generate the necessary momentum required to get the project through (Hughes, 1983).

There is a connection between slices of time that entrepreneurs might mobilize and their status as boundary spanners (Garud and Ahlstrom, 1997). An outsider is likely to have short time frames. As a consequence, they are less likely to explore. The insider, in contrast, is likely to work with long time frames. Whereas such a perspective provides a generative impulse to explore, it may also result in an escalation of commitment to a failing course of action (Staw, 1976).

Entrepreneurs who employ a boundary spanner's perspective may more likely mobilize an appropriate chunk of time

consistent with the scope of their deviation. Moreover, if one were to adopt such a perspective, it is possible to view the overall process as a series of small experiments. The feedback from each experiment serves as the bases for modifying the original idea even as additional champions are mobilized. Tenacity as a boundary spanner, then, begins addressing the thin line between persistence and undue persistence.

An ability to mobilize time as a resource offers another key benefit that has to do with timing and temporality (Schutz, 1973; March, 1991b). To mobilize time implies an ability to call upon "history" in strategic ways (see Mouritsen and Dechow, this volume). It also implies an ability to evoke images of the future in strategic ways (March, 1998; see Lampel, this volume). When entrepreneurs mobilize time in this manner, it becomes a friend rather than an enemy. Time offers entrepreneurs with an opportunity to reduce downside risk and prevents needless deployment of resources. It becomes a resource that offers entrepreneurs options to strike at the right time and right place. As a manager at 3M explained:

What does it all mean? Among other things, it means living with a paradox: persistence support for a possible idea, but *not foolishly overspending* because 3M, above all, is a very pragmatic company. It typically works this way: The champion, as his idea moves out of the very

conceptual stage and into prototyping, starts to gather a team about him. It grows to say 5 or 6 people. Then, suppose, (as is statistically the likely case) the program hits a snag. 3M will likely cut it back quickly, knock some people off the team. But as the mythology suggests, the champion is -- if he is committed -- is encouraged to persist, by himself or perhaps with one co-workers, at say a 30 % or so level of effort. In most cases, *3M has observed that the history of any product is a decade or more long before the market is really ready*. So the champion survives the ups and downs. Eventually, often the market does become ripe. His team rebuilds. (from Peters and Waterman, 1982: 230; Italix added)

Co-evolution of minds and molecules over time

Implicit in this conception of path creation is strategy as bricolage (Karnoe and Garud, 1998; Garud and Karnoe, 1999). Bricolage embodies loose coupling between actions and structure (Giddens, 1984), wherein actors probe their worlds even as they create it through "local" negotiation processes to spawn global orders. When we allow for practical experimentation coupled with thoughtful modifications, a process of bricolage, we allow for the evolution of a technological field in an emergent way (Karnoe, 1996). In this conceptualization, actors navigate a flow of events

by being mindful of when to persist and when to desist, when to credit and when to discredit, when it might be possible to make changes in the boundary conditions, all the while cognizant of the fact that they are placing bets, the outcomes to which can be only described in probabilistic terms (see also Van de Ven, Polley, Garud and Venkataraman, 1999).

Indeed, 3M appears to be a place where bricolage is encouraged as evidenced by these observations:

Our approach is to make a little, sell a little, make a little bit more... Big ends from small beginnings... spend just enough money to get what's needed next to incrementally reduce ignorance .. lots of small tests in a short interval ... development is a series of small excursions ...
(from Peters and Waterman, 1982: 231; Italix added)

This statement offers us an opportunity to clarify what we mean by mindfulness. In using this concept for specifying agency, we do not wish to imply that entrepreneurs' minds are full of details corresponding to an unyielding vision of the future. Instead, by mindful, we mean that entrepreneurs are conscious of their embeddedness and are able to depart from and indeed employ embedding structures in meaningful ways. As one 3M vice president lucidly suggested:

We don't constrain ourselves with plans at the beginning when ignorance is highest. Sure, we plan. We put together meticulous sales implementation plans. But that's after we know something. At the very front end, why should we spend time writing a 250 page plan that tries to drive out ignorance before having first done some simple tests on customer premises or in a pilot facility somewhere. (from Peters and Waterman, 1982: 232; Italix added)

Thus, fully formed plans and visions are not pre-conditions for entrepreneurial action. Instead, plans and visions emerge as a part of the entrepreneurial process. Appreciating the seemingly irrational sentiment of this position and recognizing its power in the entrepreneurial process, March (1971) aptly suggested that entrepreneurial insights may arise from a "technology of foolishness." Indeed, one can see Schumpeter's voice echoing here in our use of mindfulness:

The assumption that business behavior is ideally rational and prompt, and also that in principle it is the same with all firms, works tolerably well only within the precincts of tried experience and familiar motive. It breaks down as soon as we leave those precincts and allow the business

community under study to be faced by – not simply new situations, which also occur as soon as external factors unexpectedly intrude but by – new possibilities of business action which are yet untried and about which the most complete command of routine teaches nothing. (Schumpeter 1939, vol. I, pp.98-99)

Returning to 3M as an example of a place that encourages bricolage, Art Fry offered this insight:

At 3M we've got so many different types of technology operating and so many experts and so much equipment scattered here and there, that *we can piece things together when we're starting off*. We can go to this place and do "Step A" on a product, and we can make the adhesive and some of the raw materials here, and do one part over here, and another part over there, and convert a space there and make a few things that aren't available. (Form Nayak & Ketteringham, 1986:66-67; Italix added)

Such a process of mindful reuse and recombination of resources embedded in technological fields is similar to those offered by others. For instance, Prahalad and Hamel (1990) have alluded to the emergence of new competencies from a combination of others. Recognizing the challenges of navigating through

complexity, others have offered notions such as the "science of muddling through" (Lindbloom 1959) or "logical incrementalism" (Quinn 1978). Mintzberg, Raisinghani and Theoret (1976) are process proponents who recognize the importance of bricolage for dealing with emergent strategies. In a similar vein, Burgelman's (e.g. 1983) work offers considerable insights on autonomous approaches in contradistinction to the notion of induced approaches. More recently, Brown and Eisenhardt (1997) have offered observations on how product development efforts can unfold in an emergent fashion within minimal structures across product generations. Weick (1999) offers "improvisation" as a way of navigating and shaping emerging processes.

DISCUSSION

Entrepreneurs confront a complex flow of events where outcomes are seldom predetermined. To gain some agency in navigating and shaping the flow of these events, we offered a perspective on path creation processes. In such unfolding processes, agency is gained by endogenizing time, relevance structures and objects. More precisely, entrepreneurship requires an ability to span boundaries of relevance structures, translate objects and mobilize time as a resource. As entrepreneurs endogenize time, relevance structures and objects, they generate power to manipulate and mobilize these elements strategically. Path creation, then, is the binding of objects, relevance structures and time into an overall co-evolutionary process.¹⁹

Our perspective is not a recipe for entrepreneurial "success." We have offered a perspective based on a process logic of mindful deviation rather than on a variance logic of consequentiality. Ironically, an exclusive focus on outcomes can mute feedback generated during the entrepreneurial journey, thereby reducing the likelihood of obtaining a favorable outcome (Garud and Karnoe, 1999). Entrepreneurs have to navigate a complex flow of events in real time, fully aware that success and failure are two sides of the same entrepreneurial coin (Pinch and Bijker, 1987). Our process perspective on mindful deviations suggests that "failures" and "accidents" are powerful learning stimuli if entrepreneurs do not lock themselves into a logic of consequentiality (March, 1997).

Indeed, our perspective acknowledges the many constraints on human agency associated with entrepreneurship. For instance, unfolding structural processes suggest that entrepreneurs are creatures caught in webs of significance of their own making (Geertz, 1973). In this context, agency involves being able to discredit and disembed from these structures that enable and constrain entrepreneurs.

Moreover, attempts at disembedding are likely to generate vicious or virtuous co-evolutionary cycles. Vicious cycles are generated as negative feedback dampens entrepreneurial initiatives or positive feedback results in the generation of a momentum where the process spins out of control. Agency, from

this perspective, requires the deployment of social skills in ways Fligstein suggests, embodied in a readiness on the part of entrepreneurs to present and modify ideas to create a shared collective space.

In sum, our perspective should be viewed as one that sensitizes those attempting to create paths to the dimensions that embeds them and from which they need to disembed even as they mobilize. We cannot prescribe to what extent entrepreneurs should deviate from existing objects, nor can we say precisely how they should mobilize time or which specific boundaries they should span and when. These are all the challenges that entrepreneurs must grapple with in a mindful way as they deviate from existing technological fields.

Implications

Our perspective has several implications for entrepreneurship. Consider learning for instance. One view is that entrepreneurs should open themselves to feedback. Another is that entrepreneurs should close themselves to feedback because entrepreneurial acts imply departing from existing embedding structures. Clearly, there is a tension between these positions as is captured by a tension between commitment and flexibility (Ghemawat, 1991).

Path creation suggests a mid ground. As entrepreneurs chunk up objects, time and relevance structures, they create a series of chain linked "deviation steps." Each step explores a

deviation with a matched time frame and with relevant social groups. Having initiated a deviation step, entrepreneurs may close themselves from negative feedback in order to make progress and to generate momentum. But, once they have completed a deviation step, entrepreneurs may open themselves to feedback to reassess progress and plan modifications to subsequent deviations steps. Indeed, it is with such an appreciation between the tension between learning and creation that the CEO of Excite Company stated: "We don't worry as much about making the right decisions as we worry about making the decisions right."

A key question is -- How large should these deviation steps be? One answer is to keep them as small as possible to avoid an escalation of commitment yet large enough to gain meaningful feedback. Such a process embraces a "real options" approach to the navigation of complex dynamic flow of events (Kumaraswamy, 1996).

Our perspective has implications for other facets of entrepreneurship. For instance, entrepreneurship is not a negation of the past nor is it its simple extrapolation. It is a reconstitution and transformation of the past in such a way that continuity and change are both preserved in the act of path creation. That is, entrepreneurs are always attempting to embed out of structures that they are embedded in while re-using some of the rules and resources.

A corollary to this observation is that entrepreneurship is not a random act of genius but is a disciplined effort involving many. Entrepreneurs have to work with others by coopting them into a collective process. The notion of agency here is a relational one where credits belong to the many people offering their inputs over a period of time.

Path creation also underscores the fragility of stability. To appreciate this, let us return to path dependence. An important claim in the path dependence literature is that technological fields become locked into a trajectory because of increasing returns (Arthur, 1988; David; 1985). Consequently, from a path dependence perspective, there are many insurmountable first mover advantages. However, contemporary phenomena suggest that second movers not only catch up but even race ahead of first movers. For instance, Microsoft has been able to match and eventually overcome Netscape's first mover advantages with internet browsers. Similarly, in the case of cochlear implants, a biomedical prosthetic device, multi-channel implants could catch up with single-channel implants despite FDA approval and its lead in the market place (Garud and Rappa, 1994).

Our perspective on path creation has implications for how entrepreneurs might "design" embedding dimensions of technological fields to set in motion self-organizing organizational processes (March 1991; Nonaka 1994; Stacey 1993). For instance, they can manipulate the level and type of resources deployed for

exploration, the number and kinds of rules that are in play, the flexibility in the interpretation of rules, rules for changing the rules, and the like. In addition, the type of coupling between activities is another strategic variable (Weick, 1976). Specifically, "loose" coupling between activities sponsors co-evolutionary dynamics where there are slippages in time and space between actions in one arena of activities and actions in another. Manipulating these dimensions of technological fields can shape entrepreneurial processes such that outcomes are neither random nor determined, but a result of path creation processes.²⁰

CONCLUDING COMMENTS

We began this chapter with a process perspective on the genesis of novelty -- path dependence. We pointed out how path dependence highlights the role played by history in the genesis of novelty. We also noted how it falls short of conceptualizing the roles of actors in creating history in real time. In fact, in many studies, the role of human agency in the generative process is ignored. It is to address this lacuna that we articulated path creation.

History is still important for path creation. However the place and role of history changes. In path dependence, temporally remote events shape the emergence of novelty. With path creation, attention focuses on the efforts of entrepreneurs who seek ways to shape history-in-the-making. First, they offer "strategic" interpretations of history. Second, they actively shape emerging structures of relevance and objects, and, in the process, leave an

imprint on development efforts. Third, they evoke images of the future to "make" history in a self-fulfilling manner.

Acknowledging entrepreneurship as path creation reminds us that entrepreneurs are well aware of history and know they cannot do whatever they chose. On the contrary, entrepreneurship requires an appreciation that any effort is part of a larger ongoing and evolving process. To shape and influence these processes, entrepreneurs locate themselves at the boundaries of objects, relevance structures and time. We conceptualize the entrepreneurial role as "mindful deviation" for it is the entrepreneur who breaks away from the constraints imposed by accepted approaches and articulates and then promotes new alternatives.

INTRODUCTION TO CHAPTERS

The living language is like a cowpath: it is the creation of the cows themselves, who, having created it, follow it or depart from it, or depart from it according to their whims or their needs. From daily use, the path undergoes change. A cow is under no obligation to stay in the narrow path she helped make, following the contour of the land, but she often profits by staying with it and she would be handicapped if she didn't know where it was or where it led to. (White, 1957)

The chapters in this book approach path dependence and path creation from different disciplinary perspectives including evolutionary economics, institutional theory, complexity theory, technology sociology, and organizational sociology. They address these issues at different levels of analyses ranging from the development of regions such as Silicon Valley to the development of theoretical perspectives themselves. Many provide detailed accounts of unfolding processes to illustrate their points on path dependence and path creation. Individually and collectively, the chapters represent a unique set of articles that discuss and debate issues surrounding path dependence and path creation.

We provide a brief overview of the chapters. Our objective is not to repeat arguments in the chapters but to provide a sense of how each chapter adds to emerging views on path creation. All chapters claim to depart from path dependence. Yet some depart more from others. We have arranged the book in a manner that reflects this progressive shift. Moreover, the arrangement of chapters also serves the purpose of introducing readers to a deeper understanding of path dependence in the economics literature before grappling with other literature streams.

The first section titled *path dependence and beyond* sets the stage for understanding of path dependence in the economics literature and how and why we must extend our understanding of human agency involved in shaping the emergence of novelty. The second section titled *from path dependence to path creation* begins

departing from the epistemological and ontological positions implicit in path dependence. The third section titled *path creation as co-evolution* offers chapters that provide an appreciation of co-evolutionary processes that entrepreneurs have to manage in their efforts to create new paths. The fourth section titled *path creation as mobilization* explores how entrepreneurs might endogenize objects, relevance structures and time in their efforts to create new paths.

Path dependence and beyond

In their chapter, *When and how Chance and Human can twist the arms of Clio?* Bassanini and Dosi explicate issues around path dependence as they appear in the economics literature. In doing so, Bassanini and Dosi highlight the overtones of determinism implicit in the path dependence perspective. Specifically, proponents of the path dependence perspective appears to place too much emphasis on initial conditions in shaping the emergence of novelty; they often neglecting the power that "chance events" and "human will" can play in unlocking paths. Arguing for a stochastic approach, Bassanini and Dosi offer several forces that might result in the unlocking of paths. These forces include: (1) new technological paradigms, (2) heterogeneity among agents (3) co-evolutionary nature of socio-economic adaptation, and (4) invasion of new organizational forms from other contexts.

Following Bassanini and Dosi's introduction to path dependence in the economics literature, we thought it might be useful to see how other disciplines have dealt with matters concerning history, time and temporality. In their chapter titled *Unpacking Path Dependence* Hirsch and Gillespie point out that there is a long and rich tradition in the social sciences of examining the role of history in shaping contemporary phenomena. They suggest that our current emphasis on contextual, historical, evolutionary perspectives in the social sciences is a return to theories that dominated at the turn of the last century which "lost out" for some time to perspectives that celebrated the rational actor and others that were built around structural perspectives. Hirsch and Gillespie suggest that scholars of innovation and technology should incorporate and integrate the differential valuations accorded history and temporality across social science disciplines, especially from anthropology, economics, history, management, political science, and sociology. An important contribution here is that an awareness of differential weights accorded to history by each discipline can potentially liberate proponents of each discipline from path dependencies. Stated differently, an understanding of the meta-framing implicit in each of the theoretical perspectives is an important first step for scholars to generate agency in their abilities to create new theoretical paths. In the end, they argue for "path as process," meaning technology is a

forever emergent, non-recursive product of path creation, path destruction, and path dependence.

After Hirsch and Gillespie's tour of path dependence and path creation in the social sciences literature, we return to the economics discipline once again to trace its historical development. Providing this historical perspective is Vernon Ruttan, whose work on induced innovation models of change has inspired many of us to think about and articulate positions on path creation (cf. Ruttan, 1979). In his chapter titled *Sources of technical change: Induced Innovation, Evolutionary Theory and path dependence*, Ruttan identifies critical junctures in the development of theories of technological change and locates path dependence in this larger mosaic of ideas associated with the development of economic theory. He illustrates how there has been different uses of history in the economic discipline itself and suggests how and why we must think of path creation models as we move forward.

From path dependence to path creation

In their chapter, Kenney and Burg apply the path dependence perspective to study the evolution of Silicon Valley. Consistent with path dependence, their explanation highlights the sensitivity of unfolding processes to initial conditions. At the same time, Kenney and Burg extend the traditional path dependence model by exploring how institutions such as venture capital, law firms, marketing firms co-evolved. Kenney and Burg suggest that

this institutional context of resource-formation and firm structuration is a process that is continually evolving with technologies and industrial forms. A key contribution is to illustrate multiple path dependent processes at work, each shaping the other. Path dependence, if constructed as a relatively one-dimensional model, does not do full justice to the manner in which Silicon Valley emerged as an eco-system.

In *Standards, Modularity, and Innovation: the Case of Medical Practice*, Langlois and Savage discuss a familiar class of increasing-return processes: the setting of standards. In this case, however, the standards are not the usual technological ones but rather standards understood as behavioral routines. Standardized routines are in fact a well-known form of social institution, and social institutions are quite generally a form of social institution giving rise to increasing returns. The case at hand is the setting of medical standards, both the coordinative standards that have guided the medical profession but also the normative standards that have attempted to assure quality. Langlois and Savage argue that, because of the overwhelming efficiency advantages of a decentralized professional structure, the medical standards of the early century took the form of rules and routines guiding local practitioners rather than a top-down monitoring system, e.g., through hospitals or professional associations with strong central authority. The chapter argues that this was a desirable system in that it proved open enough to allow the rapid learning of skills and

the invention of new practices and technology. This instance of standard-setting was in fundamentals a case of path dependence, as alternatives were both imagined and tried. This is not, however, a case much like QWERTY is supposed to have been, in that - in the authors' view - it was not small changes in initial conditions that tipped the balance but rather a clear-cut advantage to the system adopted - advantages of both a static and a dynamic sort. It is only now with the changing "architecture of revenue" (to use John Seeley Brown's phrase) in health care that the decentralized institution-based system of normative standards may be giving way to centralized monitoring in the era of managed care.

Baum and Silverman apply complex adaptive systems theory to technological evolution. To do so, they shift attention from competitive outcomes (i.e., content) to innovation trajectories (i.e., process). Baum and Silverman show how innovation trajectories produced by competitive interorganizational systems can be related to concepts from complexity theory, and illustrate the range of possible innovation trajectories (or macrostructures) -- ordered, chaotic and random -- such systems can produce. They highlight the tension between exploitation of knowledge gained (path dependence) and exploration of novel actions (path creation) and show how innovation processes characterized by chaotic behavior balance these tensions, permitting adaptive functioning of competitive interorganizational systems. Can innovation process dynamics thwart lock-in or provoke de-locking on such

technological fitness landscapes? Baum and Silverman suggest that it should be possible to 'tune' the innovation process to avoid the danger of becoming trapped on poor local optima. For example, lock-in may be avoided by partitioning the problem into sub-tasks each of which optimizes while ignoring the effects of its actions on the problems facing other subtasks. Sub-task boundaries permit constraints from other subtasks to be ignored, helping to avoid becoming trapped on poor local optima. Overall performance arises as collective emergent behavior of the interacting, coevolving subgroups. Such 'co-evolutionary problem solving' is not useful for simple problems, but increases in value as landscapes become less differentially rugged. This proposal is equivalent to recommending that organizations facing difficult problems divide into departments, profit centers, and other quasi-independent suborganizations to improve performance. In sum, Baum and Silverman think research on 'tuning' innovation process dynamics to technological problem domains will provide basic new insights on technological evolution.

Path creation as co-evolution

In their chapter titled *America's Family Vehicle: Path Creation in the US Minivan Market* Porac, Rosa, Spanjol, and Saxon, argue that markets are fundamentally socio-cognitive in nature. Markets are created when potential buyers and sellers connect around an artifact, and, in the process, represent the artifact as a conceptual system that defines its attributes, uses, and

value. Porac and his colleagues suggest that a socio-cognitive conceptualization of markets provides a robust frame for answering theoretical questions that have so far been intractable. For example, how and when is a market created? In a socio-cognitive perspective, such conceptualizations emerge and stabilize through conversations and narratives across producers and consumers; specific artifacts and behaviors become associated with consensually understood market categories. Even as they study the creation of new markets, Porac and his colleagues claim empirically that a weak form of path dependence shaped the automakers' choices of car-design and use-situations when the minivan market was "re-created" in the early 1980's. For instance, new product markets were based on a mobilization and re-use of "old" product categories from the 1940s. Porac and his colleagues suggest processes involved with path creation by addressing questions such as "How do market categories evolve and change and how and why do product categories die?" Addressing these questions, Porac and his colleagues suggest that change occurs in the knowledge structures around which markets cohere such that new attributes become associated with existing artifacts or new artifacts become assimilated into existing structures. Categories die when a market's underlying knowledge structures no longer cohere in a meaningful and profitable way.

In their study of the construction of new paths in the automobile and biotechnology industries, Rao and Singh focus on

the political-institutional processes whereby goals, authority structures, technological artifacts, and consumers are mobilized to create paths. In their chapter titled *The construction of new path creation: Institution-building activity in the early automobile and bio-tech industries*, Rao and Singh turn away from random theory to embrace a institutional cultural-frame. Such a perspective is co-evolutionary, one where social agents have some power to generate new paths. Their study illustrates an important point about emerging technological fields: that technology, preferences, social groups do not pre-exist. Indeed, new technological fields are realized through a process of mobilization and testing and the settling of controversies among engineers making the “hardware” work according to evaluation standards that emerge in a co-evolutionary manner. The process of mobilization is about building legitimacy among involved social groups where the settling of controversies produces temporal closure around a new technology.

In their chapter *Constructing transition paths through the management of niches* Kemp, Rip and Schot explore how political intervention can create new technological paths. Their key concept, strategic niche management, focuses on the role played by state regulators to create and nurture technological paths. To do so, state regulators must shape co-evolutionary processes associated with the emergence of artifacts, user groups and institutional rules. Niches are "protected spaces" where entrepreneurs re-use accumulated knowledge and capabilities, one where regular market

conditions do not apply because of special R&D and market subsidies. Gradually, protection may be erased and ‘real’ market conditions introduced. The role of energy and technology policies in shaping emergence of the wind turbine fields in Denmark and the US between 1974-1990 serves as the empirical basis for these recommendations.

Path creation as mobilization of resources

Lampel's chapter *Show-and-tell: Product demonstrations and path creation of technological change* offers ‘technological dramas’ as an approach to shape relevance structures to generate momentum for a new technology. Lampel uses historical case studies to examine processes underlying these technological dramas. Technological dramas may trigger collective adaptive expectations around a technological trajectory. Lampel suggests that innovation success depends on bridging the specialized domains of inventors on the one hand and technical experts with the larger world of investors and consumers on the other. All this happens by appealing more to the "non-calculative" part of the human mind: to affect, imagination, or fantasy, so choices are based on a commitment to the future, as much as a proper evaluation of the present. Through such dramas, technology entrepreneurs attempt to initiate a bandwagon that can jumpstart the generation of a technological trajectory. These dramas generate images of technologies that circulate through private and public channels of communications giving shape to the identity of the

new technology even before it has been established as an accepted part of economic reality.

In their chapter *Innovation as a community-spanning process: looking for interaction strategies to handle path creation*, Van Looy, Debackere and Bouwen examine micro-level process associated with boundary spanning between and across communities of practice. Communities of practice are characterized by shared beliefs, evaluation routines and artifacts. Consequently, they create powerful path-dependencies that might inhibit path-breaking innovations. To understand the effect of boundary-spanning actions on path dependence and path creation, Van Looy and his colleagues suggest paying closer attention to the antecedents and the consequences of micro-level interaction patterns between communities of practitioners. At this level of analysis, the fragility of stability becomes clearer. Indeed, their empirical study shows how a spectrum of community-spanning interaction patterns lie at the origin of path creation processes.

Mouritsen and Dechow's chapter *Technologies of Managing and the Mobilization of Paths* illustrates how "world class" supplier relationships produce new practices and organizational rules in two firms that they study. Based on Giddens structuration and actor-network theory, they suggest that "world class" as a concept does not have *apriori* meaning and that it has to be gradually defined through translation processes. "World class", thus, has to be given meaning through action. They demonstrate

how firms' past histories are mobilized and constituted as part of this process. History is interpreted and re-interpreted by organizational actors in strategic ways. Indeed, translation processes involve the bridging of boundaries in such a way that key stakeholders gain a voice in the emerging network, and, in the process, define what is "world class" through their interactions. History, as an interpretation of the past, becomes a key resource which is drawn upon even at it is being made.

Pinch uses the social construction of technology (SCOT) literature in his study of the early emergence of electronic music synthesizers *Why go to a Piano Store to Buy a Synthesizer: Path Dependence and the Social Construction of Technology*. Pinch's "follow the actor" approach generates insights on the many facets associated with the emergence of a synthesizer. His study illustrates that, as with other technological fields in the making, the technology, customer preferences and relevant social groups do not pre-exist. In this regard, it is interesting to note that even the inventors of the synthesizer, Moog and Buchla, had very different visions. Indeed, the new technology emerged through a co-evolutionary process involving a heterogeneous set of objects and people. Pinch describes how the new type of sound generated by the synthesizer was perceived as "weird shit" because it deviated from the then existing notions of what was considered to be "music." His description provides an appreciation of the importance of time for this weird sound to become accepted by a

larger social group. During this time frame, many actors played a role in using synthesizers. Pinch's description is a story of path creation, one where reflective entrepreneurs mindfully tried to navigate a flow of events that they attempted to shape. Indeed, Pinch's study demonstrates the interactive nature of the three dimensions that we have introduced earlier -- objects, relevance structures, and time -- within which actors are embedded, and from which they disembed.

The end of a new beginning

Each chapter is richer than the descriptions that we have offered. Each contributor takes a process view, one where it is important to accord some agency to humans in their abilities to shape the emergence of novelty in real time. Together, the chapters represent a mosaic of ideas that help build a perspective on path creation as a process of mindful deviation. Indeed, the chapters are an inspiration to all of us, encouraging us to engage in more studies that enrich our understanding of processes associated with the emergence, stabilization and erosion of paths.

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End Notes

¹ We define a 'technological field' as representing a pattern of relationships between artifacts and humans related to any product-market domain (Karnoe, 1999). Actors in a technological field may have different structures of relevance and yet be a part of the same technological field. In our use of technological field, we depart from a "common meaning system" implicit in the concept of an "organizational field" in neo-institutional theory (Scott 1995:130).

² As Latour (1992:120) points out, "Both economics and stable sociology arrive on the scene *after* the decisive moments in the battle....Since the explanation of an innovation's path cannot be retrospective, it can only spring from the socio-logics of programs and anti-programs."

³ Technology inter-relatedness means the complementarity and compatible of system parts. Economies of scale alludes the benefits that arise from size. Quasi-irreversibility of efforts means difficulties associated with re-deploying an asset for alternative purposes.

⁴ In contrast, a path independent phenomenon is one where the sequence of events has no implication for the eventual outcome that unfolds (Langlois and Savage's analysis of the American Medical Profession in this volume comes close to describing such a path independent process).

⁵ Liebowitz and Margolis even challenge the completeness of David's description of the emergence of the QWERTY keyboard.

⁶ We have been influenced by Tsoukas (cf. 1996)

⁷ Deviations in any of the embedding dimensions (viz. objects, relevance structures and time) may set path creation processes in motion. For instance, any change in institutional regulations may set in motion a sequence of adjustment in objects over time. Similarly, as March (1998) suggested, if actors in a technological field are able to mobilize time as a resource, it may set in motion exploratory acts that, in turn, change institutional arrangements. The symmetry involved in entrepreneurs being able to set path creation processes in motion by being able to manipulate any of the embedding dimensions should not be much of a surprise. After all entrepreneurship involves managing co-evolutionary dynamics that are set in motion when they attempt to disembed from their embedding dimensions. Indeed, this symmetry is advantageous in developing a more complete theory of entrepreneurship where one might conceptualize path creation processes being set in motion by the action of actors in domains of use, production and governance, and one which

eventually encompasses a collective with heterogeneous interests. See chapter by Kemp, Rip and Schot in this volume for how regulators can set path creation processes in motion.

⁸ See Hirsch (1975), Rao (1994)

⁹ Schutz (1973: 240) states that the merits of any object must be understood as: "relational notions and have to be defined in terms of the domain of relevance to which they pertain. Only within each of these domains of relevance can degrees of merit and excellence be distinguished. Moreover, that which is comparable in terms of the system of one domain is not comparable in terms of other systems, and, for this reason, the application of yardsticks not pertaining to the same domain of relevance leads to logical or axiological (moral) inconsistencies." This is closely related to the concept 'provinces of meaning.' Schutz points out: "We speak of provinces of *meaning* and not of sub-universes because it is the meaning of our experiences and not the ontological structure of the objects which constitutes reality." This concept of relevance structures is similar to Blumer's notions of how meanings are attributed to 'objects' by 'fellow men.'

¹⁰ Here we see an important overlap with Dewey's pragmatism. Dewey's view is that entities are interdependent and interrelated and that any isolation of entities are mental constructions. Dewey puts a primacy on the entities in interaction: "The materials of our everyday surroundings need to be woven together so that they do not merely accumulate, but rather culminate in a set of habits that provide meaningful ways of interacting with those surroundings." (From, Boisvert 1998:124). Boisvert comments that in Dewey's perspective, we live in and constitute a world that is continually in-the-making, "Affairs are never frozen, finished, or complete. They form a world characterized by genuine contingency and continual process. A world of affairs is a world of actualities open to a variety of possibilities" (Boisvert 1998:24). Further, Boisvert points out "Since all entities are entities-in-process, they are continually being influenced and altered by the relationships into which they are immersed. The various projects we undertake, relationships into which we enter, and struggles which we undergo, help shape who we are" (Boisvert 1998:23).

¹¹ Several scholars have embraced this perspective within a literature stream that is commonly referred to as the "actor network theory" (see for instance, Callon, 1986; Latour, 1987; Law, 1992)

¹² Blumer presents three premises of symbolic interactionism: "The first premise is that human beings act towards things on the basis of meanings that the things have for them. The second premise is that the meaning of such things are derived from, or arises out of the, social interaction that one has with one's fellows. The third premise is that these meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things he encounters" (Blumer's (1986:2).

¹³ It is here that one can see how we intend to use some of the apparatus that the path dependence perspective offers. Path dependence is also built around non-linear dynamics. Whereas proponents of the path dependence perspective are interested in describing phenomena shaped by non-linear dynamics, we are interested in the implications of these dynamics for action within the system.

¹⁴ Changes in objects and rules that constitute a technological system can also set in motion a chain reaction that brings about change in the technological field (Callon, 1992:141). In this paper, we are interested in understanding the role of human agency in navigating and shaping such co-evolutionary processes.

¹⁵ Sitkin and Brown make a similar point in their presentation of the Xerox case at the 1999 Academy of Management Meetings, Chicago.

¹⁶ See Amabile (1996) for insights on how intrinsic motivation can give rise to persistence.

¹⁷ This conceptualization is similar to the notion of "organizational field" in institutional theory as comprising a shared set of meanings (Scott, 1995). However, in our conceptualization, a shared space in the technological field does not necessarily mean an unitary relevance structure. Instead, it implies a negotiated and sometimes precarious understanding between people with different frames of relevance.

¹⁸ We build upon Feldman and March (1981).

¹⁹ Both "success" and "failure" must be explained with the same model (Pinch and Bijker 1987). In our conceptualization, efforts at creating paths succeed when there is a binding of objects, relevance structures and time into an overall co-evolutionary process resulting in the emergence of a 'technological field'. "Failures" are more likely to occur when entrepreneurs are unable to create these linkages; they are not necessarily a result of some intrinsic property of an artifact.

²⁰ See Garud & Jain (1996) Dooley & Van de Ven (1999) and Baum & Silverman (2000) for descriptions of different embedding states.