The Role of Competencies, Contexts, and Constraints in Creating Opportunities from Disruptive Technologies

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Research on decision-making by entrepreneurs under conditions of high uncertainty suggests they rely on their unique competencies and adopt resource-conserving contingencies when assessing opportunities. In the context of commercializing disruptive technological innovations, this implies that opportunity is primarily defined and bounded by an entrepreneur's prior experience and existing capabilities and resources rather than by the innovation's unique properties. Some argue this artificially limits the discovery of viable opportunities, but the findings in this study suggest it actually facilitates creating an opportunity that provides the entrepreneur with best chance at a successful commercialization outcome.

EXECUTIVE SUMMARY

The successful commercialization of a technological innovation is a nuanced and path dependent process (Van de Ven et al., 2000) with many viable ideas, applications, and markets competing for an organization's limited resources (Van de Ven, et al., 1999). Shane (2000) discovered that variances in opportunity identification and assessment processes appear correlated to differences in entrepreneur / team expertise and experiences. The opportunities pursued by each team licensing three dimensional printing technology from MIT were unique and significantly influenced by the expertise, networks, and past experiences of team members (Shane, 2000). Sarasvathy (2001) argues that when the degree of market uncertainty is exceptionally high entrepreneurs rely on a process of effectuation - attempting to control outcomes through *who they know* and *what they know* rather than predict outcomes - to define and make decisions about opportunities.

The findings from observing participants in a (U.S.) Pacific Northwest university program assessing the commercial potential of technological innovations support Sarasvathy's argument and suggest that effectuation may be a key factor in the variance in opportunity assessment observed by Shane (2000). The results further suggest that impending deadlines and key milestones, what Van de Ven, et al. (1999) characterize as periods of convergence, heighten the influence of existing expertise and past experiences on opportunity definition and assessment. It also appears that decision-making based on effectual reasoning, combined with the need for action triggered by periods of convergence, actually improves the chance of creating a viable commercial application.

INTRODUCTION

Research on the relationship between innovation, new product development, and firm success has typically (and often implicitly) assumed that actors: (1) discover market opportunities through careful

scanning of (existing or potential) customers and competitors using traditional research tools, (2) carefully estimate the resources required to pursue different potential markets, (3) assess the probabilities of success for each viable alternative, and (4) make decisions based on achieving an optimal return on investment (Im and Workman, Jr., 2004). This paradigm differs significantly from research on the successful commercialization of technological innovations that suggests the process is far more subjective and path dependent (Van de Van, et al., 2000).

The literature on innovation does not consistently differentiate between its various forms (e.g. Katila and Ahuja, 2002) but there appears to be some agreement on the characteristics of radical innovations. For example, Chandy and Tellis (2000) drew upon several other definitions (e.g. Damanpour, 1991; Gatignon and Xuereb, 1997; Henderson and Clark, 1990) in defining a radical innovation as one where the core technology varies substantially from the previous product generation. This is in contrast to incremental innovations, which enhance or build upon an existing technology (Chandy and Tellis, 2000). In addition, and more critical to successful commercialization, radical innovations must provide eventual customers with far greater value relative to existing products (Chandy and Tellis, 2000). This definition is consistent with the Anderson and Tushman characterization of technological discontinuities as innovations that "dramatically advance an industry's price vs. performance frontier" (Anderson and Tushman, 1990, p. 604). Utterback (1996) also uses the term discontinuities to refer to market disruptions triggered by radical innovations.

Radical innovation is also described in the context of products, processes, and industry and market characteristics. Urban et al. (1996) define *really new products* as producing shifts in market structures, representing new technologies, requiring customer learning, and inducing behavior changes. Song and Montoya-Weiss (1998) define a really new product as relying on technology never used in the industry before, causing significant changes to that industry, and being the first offering of its kind in a market. Griffin and Page (1996) define new to the world products as those that create an entirely new market. The most important characteristics revealed by these definitions are that radical innovations are based on new technologies that make it possible for applications which can: (1) create new markets / industries, or (2) disrupt existing industries and markets.

In the disruptive innovation context entrepreneurs / teams are typically confronted with many more potentially viable applications and markets for a given innovation than they can address with the resources at their disposal (Van de Ven, et al., 1999). Variances in opportunity assessment, pursuit, and outcomes are significantly shaped by differences in start-up team member expertise, past experiences and the context in which a decision is being made (Shane, 2000; Van de Ven, et al., 1999). For example, Shane (2000) examined how a technology developed at MIT, three dimensional printing, resulted in several start-up teams pursuing equally viable but distinctly different product and market opportunities. Shane discovered that the choice of opportunity was significantly influenced by the team's technical and managerial expertise, existing contacts and networks, and past experiences.

Are Entrepreneurs Hindered or Helped by Their Limitations?

Shane implies that differences in expertise, experiences, and networks produce cognitive limitations for entrepreneurs in identifying and assessing opportunities. Sarasvathy's (2001) concept of effectuation offers a potential alternative or complementary explanation of why entrepreneurs decide to pursue a specific market opportunity. Sarasvathy argues that when entrepreneurs are confronted with a high degree of market uncertainty they rely on *who they know* and *what they know* in deciding on which opportunities to pursue. In other words, entrepreneurs in these dynamic market environments choose between possible effects (outcomes) that can be created with their given means (Sarasvathy, 2001). This implies the entrepreneur is acting rationally by creating an opportunity that is ideal for their circumstances rather than simply attempting to discover the ideal application based on some apparently immutable quality of the technology. The salience of this approach should be especially true when opportunities are based upon applications of disruptive technologies for which there is no clear market precedent.

Santos and Eisenhardt (2005) seem to concur, as they argue that most theories of markets and firms assume an existing industry structure and established organizations operating within that industry's

boundaries, but "market boundaries in particular are not exogenous but rather shaped by entrepreneurial actions" (Santos and Eisenhardt, 2005, p. 3). In nascent markets "organizational and market boundaries are intertwined and co-constructed" (Santos and Eisenhardt, 2005, p. 3) and entrepreneurs are "not entering a new market" or "discovering a hidden market" (Santos and Eisenhardt, 2005, p. 16), "rather they are trying to make their conception of the nascent market socially understood and accepted" (Santos and Eisenhardt, 2005, p. 16). Thus the market is not simply exogenous to the firm; each shapes the other as entrepreneurs actively co-construct and define market boundaries (Santos and Eisenhardt, 2005).

In summary, it appears that entrepreneurs assessing opportunities based on applications of technologies with the potential to disrupt or create markets managing their risk and maximize their chances for success by focusing on contexts which are familiar to them based on past experiences and on opportunities that best leverage their expertise and available resources. While prior experiences, domain of expertise, personal and professional networks, and available resources may effectively limit the ability to assess a wide variety of alternatives as suggested by Shane, it is unclear whether this creates a disadvantage or, through effectuation, actually produces a necessary focus on opportunities which are most viable for that particular entrepreneur. A two-year observation of the opportunity assessment process at a university in the (U.S.) Pacific Northwest sought to explore the extent to which experiences, competencies, and constraints (primarily resource and time) are either hindrances or assets in the opportunity assessment process. The findings suggest that while the capability to assess a broad range of opportunities may be hindered, the prospects of identifying commercially viable opportunities which the entrepreneur can actually pursue are significantly improved. What follows is a summary of the study, the key findings, conclusions drawn, and potential implications.

STUDY OVERVIEW

The study sought to examine three key questions:

1. Would the teams exhibit the opportunity assessment characteristics as observed by Shane (2000)?

2. Would the processes teams used to define and assess opportunities be consistent with an effectuation (Sarasvathy, 2001) approach to decision-making?

3. (How) would program requirements – especially deadlines / key milestones with deliverables – influence decision-making and the assessment process?

What follows is an overview of the data collection process.

Research Design: Semi-Natural Experiment via Technology Entrepreneurship Program

The setting chosen for this study was a program at a university in the (U.S.) Pacific Northwest where graduate (MBA and Law) students assess the commercial potential of technological innovations. A total of six teams evaluating potential applications and markets for technological innovations were observed over a period of two years. The three teams examined during the first year of the study assessed opportunities for three different technologies. A new group of three teams observed in the second year assessed opportunities for the same technology. While data on the first three teams was collected after the teams had already completed the initial assessment process, data on the second group of teams was collected at the start and throughout each stage of the process. Despite these differences the findings were remarkably similar between the two groups of teams.

The program is a collaborative effort between the University's College of Business, School of Law, Office of Technology Transfer, and the Battelle Memorial Institute. MBA and Law students are selected via a highly competitive process to participate in the program. The participants are assigned to teams that assess the market feasibility of technologies developed by scientists at both the University and the Pacific Northwest National Laboratory (PNNL), which is managed by Battelle. At the conclusion of an intensive

three-month assessment process the teams recommend a specific commercial application and market opportunity. Following this process, some teams recruit additional members to assist in developing business plans based on the opportunities identified through the assessment process.

In the first year of observation, one of the three teams did not advance beyond the assessment stage, while in the second year only one team advanced to the business planning stage. This situation was somewhat fortuitous in that it allowed me to compare and contrast the experiences of teams who were actively pursuing an opportunity and those who were not. This is contrast to the study by Shane (2000) in which all teams in the study were actively attempting to commercialize the technology. Of the three teams that continued working on a business plan, all three went on to compete in (and in two cases win) multiple national and international business plan competitions, while members of two of those teams have launched ventures based on their business plans. These outcomes are an indication of both the viability of the opportunities selected by the teams and the capabilities of the students who participated in the program.

The program provided a unique setting for a semi-natural experiment with built-in controls, as each team has the same limited financial resources, number of team members (at the opportunity identification stage), basic qualifications (graduate students), program-imposed guidelines, access to expert advice, and deadlines. As a result the detected differences in team opportunity selection processes were primarily a function of team dynamics (evidence of cohesion, consensus-building, conflict, turnover and changes in team composition) and differences in team member expertise and experiences. The impact of decision-making environment created by the requirements and guidelines imposed by the clients / sponsors of the program was also examined. A potentially significant influence, social and business contact networks, was not directly examined as uncovering and mapping these networks exceeded the scope of the study. However, the influence of contacts and networks was explored and documented whenever possible. Other factors that can influence the direction and function of a team are each participant's level of creativity, perseverance, leadership, and ability to persuade or build consensus. An examination of these factors was incorporated by detecting their presence in an individual's prior accomplishments and their manifestation in the team.

Document Analysis

The project was initiated with an analysis of available documentation on the backgrounds of the participants, the technologies evaluated, the requirements and guidelines imposed by the program, and the progression of the process, from teams gaining familiarity with technologies to the generation and evaluation of alternatives and selection of a specific market opportunity.
The most informative documents were:

- Team member resumes and overviews of the technologies evaluated
- Each team's submission of three phases of progress reports and a final recommendation (including presentation materials)
- Examples of the extensive research conducted by the teams in evaluating applications of the technology and market opportunities
- Examples of decision making criteria developed and implemented by teams

Document analysis was particularly useful in achieving basic knowledge of the backgrounds of the participants, the overall structure of the evaluation process and requirements imposed by program advisors and sponsors, and the evolution of the process. The analysis also helped identify additional questions to pursue during interviews with representatives from each of the teams. In particular, it was important to find out how the structure of the program impacted participant decision making, and whether the skills and motivations which participants documented as being important actually manifested during the assessment process.

Observation

First year observations included meetings between the primary program advisor and the two teams which had decided to develop business plans based on the opportunity selected during the assessment process, as well as vetting sessions in which each team delivered the latest version of their presentation before a guest advisor (typically a venture capitalist). The intent of these sessions was to help the teams sharpen their presentations for upcoming business plan competitions. Second year observations included three rounds of presentations by each team, individual team meetings and sessions with program advisors throughout the assessment process, as well as a trip to PNNL where the teams met with the organization's scientists.

Interviews

While document analysis and observation proved very useful in understanding the overall environment in which the participants were operating, the greatest insights came through interviews with program participants. The interviews were particularly successful in achieving a greater understanding of how team dynamics, expertise, and prior experiences as well as the structure and demands of the program influenced the team's decisions. Four (4) semi-structured depth interviews were conducted during the first year: three (3) with program participants, the fourth with the primary program advisor. One of the individuals interviewed was originally on the now disbanded team and had since joined one of the surviving teams for the business plan stage. He was able to provide a unique perspective by comparing and contrasting his roles and experiences on both teams. The interviews averaged 45-60 minutes in length. All participants were granted anonymity. The interviews were audio taped and then transcribed.

A total of ten (10) semi-structured depth interviews were conducted in the second year, with at least one member from each team interviewed. Six (6) interviews were conducted at approximately the midpoint of the assessment process. The interviews focused on understanding the basic criteria and approaches that the teams had used to identify potential applications and markets. Four (4) interviews were conducted at the conclusion of the program and those interviews were focused on asking participants what elements of the process they found most challenging, what they saw as the keys the to the successful commercialization of technologies, and what advice they would give future program participants. The initial interviews averaged 30 minutes in length, while the follow-up interviews were approximately 45 minutes. All participants were granted anonymity. The interviews were audio taped and then transcribed.

FINDINGS

Experiences, Expertise, and Motivation Shape Opportunities

The prior experiences and expertise of the individual program participants not only influenced their ultimate choice of a specific application and market opportunity, but also the process by which alternatives were generated and assessed. Overall, the teams were balanced with roughly equal representation of males and females and by current degree being pursued (MBA or/and JD). Each team included individuals with some technical expertise and general business experience. The program administrators responsible for forming the program teams were cognizant of the differences in the backgrounds of the individual participants, and they made a conscious effort to put together teams with complementary skill sets. In the interviews I detected that individual participants were attuned to each other's relative strengths and weaknesses.

A further examination of individual backgrounds of the three teams in year one revealed potential correlations between areas of experience, expertise, and interest and the ultimate opportunity selected by two of the three teams. For example, one team had two individuals with an engineering background, in civil and industrial engineering. This team, like all the teams, explored a wide variety of applications for their technology, which converts changes in ambient temperature into electrical energy. They ultimately targeted a primary market that addresses the remote sensing of the structural integrity of bridges and pipelines. This opportunity was the most aligned with the knowledge set of the two former engineers.

Each member of another team had some experience or interest in the environment and environmentally friendly business practices. This team's choice of opportunity was significantly influenced by the potential application of their technology (a chemical enzyme "cleansing" process) to *green* processes such as the production of biofuels. This team ultimately selected an application that removes hazardous chemicals from wood treated with preservatives. The leader of this team had previously worked in the wood products industry. It is interesting to note that these influences appear to have operated on a seemingly subconscious level. When one of the interviewees was asked to comment on how two of the teams picked opportunities in which at least one of the team members had some expertise, he replied "funny how that worked out..."

The experiences of the third team are perhaps the most illustrative of how prior experiences and expertise shaped both the ultimate outcome and the processes used to get there. This team was the least organized, focused, and technically savvy of the three; while each team struggled with getting a firm grasp of the potential of the technologies they evaluated, this group had the most difficultly. The team finally gained traction when they found an application for their technology within a context they could understand: developing "smart" fabrics (that can sense body temperature, heart rate, etc.) for performance (sports) apparel. While most of the alternative applications they explored were far removed from their collective expertise and experiences, each member of the team had a basic consumer-oriented understanding of apparel. In addition, they had connections to and were familiar with the operations of performance apparel and active wear companies such as NIKE and Columbia. Armed with new found confidence in their ability to effectively and intelligently explore this application, the team was able to successfully identify a viable market opportunity.

The three teams from the second year exhibited a similar pattern of choosing market opportunities that matched personal interests, skills, or areas of expertise. One key distinction between these three teams and the first trio of teams is that each team ended up identifying a unique opportunity for the same technology, a situation comparable to what Shane (2000) observed (multiple and distinct applications of the same licensed technology). The technology, a genome sequencing process developed by a University professor, has several potential applications in plant and animal breeding. One team decided to focus on the grass seed market because it was a major crop in the state and one of the individuals on the team had connections in the industry. Another team focused on applications for nurseries, and a primary motivation was that the family of one of team members was in the nursery business. The third team focused on potential applications for horse breeding. None of the team members had expertise or direct experience in this market, but one member had a strong interest in horse racing and his team decided to focus on breeding after speaking to someone at the university whose family raises and races horses. Thus in each instance teams eventually relied on a decision making frame of reference based on their expertise, experience, knowledge, or personal connection to the market opportunity.

Degree of Uncertainty Necessitated an Effectuation Approach to Decision-Making

Most of the participants in the program seemed to have received prior education or training that emphasized the primacy of market forces and intellectual property protection in determining the attractiveness of a market opportunity. Those assumptions were challenged during the assessment process. For example, the teams initially focused on seeking readily identifiable existing market needs for the technologies. Several individuals mentioned the identification and fulfillment of articulated customer needs as a key marketing principle. In effect, the teams were trying to find an optimal solution to the commercialization challenge posed to them. The primary advisor to the teams in the program noted that the teams faced a unique challenge because the program gave them a technology-based solution looking for a problem instead of a problem to solve with a technology-based solution. This approach is counter-intuitive to how MBA students are normally instructed, in which the first step to any process is a clearly defined statement of the problem. However, potentially market-disrupting technologies most often result from achieving technological breakthroughs or solving scientific problems that then must be translated into viable market solutions.

By the end of their opportunity assessment process most of the participants had come to believe that there are no clearly superior market opportunities inherent in a given technology. As previously noted, the teams were eventually able to identify market problems for their technologies to solve by framing them in familiar contexts. After realizing that their initial approach was generally ineffective, each team eventually shifted their focus from attempting to predict the most compelling market needs to opportunities and markets in which they had the greatest experience, expertise, or connections. In other words, they shifted to a decision-making logic of control consistent with effectuation (Sarasvathy, 2001). This shift was instrumental in helping teams successfully move forward with their projects, with the most dramatic example being the team from year one which struggled until finding an opportunity they understood in the context of their prior experiences, competencies, and contacts. It also important to note that unlike the teams in Shane's study (2000), the teams in this study did explore a myriad of opportunities in markets unrelated to their eventual choice. So these teams were not hindered by cognitive limitations in the exploration of opportunities, but rather the sheer number of potential opportunities to consider and the team's inability to accurately assess potential outcomes significantly hindered their ability to settle on one. By adopting a decision-making approach consistent with effectuation the teams were able to overcome this cognitive hurdle and move forward with a viable market opportunity. Project deadlines and deliverables played a key role in hastening the fundamental shift in decision-making logic from prediction to control, as discussed in the following section.

Deadlines and Deliverables Trigger and Amplify the Role of Effectuation

As previously noted, three teams proceeded to develop into a more detailed business plan based on the opportunity they identified. These teams relied on and had the most confidence in their expertise and prior experiences to effectively wade through an otherwise overwhelming amount of information and possibilities. Looming project deadlines and specific deliverables provided the motivation and boundaries in which the teams developed and applied their decision making rules and skills. In contrast, the team which struggled most demonstrated the least confidence in its decision making capabilities, resulting in a significant amount of floundering in what seemed to be a futile search for *the* right application.

Each team progressed through the same multi-stage process of selecting a technology, investigating applications for that technology, examining markets for those applications, and ultimately selecting a specific combination of application and market as their primary business opportunity. The structure, deliverable requirements, and deadlines of the program had a significant influence on individual and team decision making processes. These constraints on the teams seemed to force them to come up with decision making heuristics. These heuristics were needed to effectively manage a flow of information and alternative courses of action that taxed the capacity and processing capabilities of the teams while still producing viable and sound business decisions. Deadlines requiring specific project deliverables at each stage to assure progress towards a culminating presentation of a specific market opportunity provided the motivation and boundaries in which teams developed and applied their decision making rules. The adoption of an effectuation approach to decision-making in response to deadlines and producing deliverables was essential to reducing the complexity of sorting through alternatives and selecting a viable opportunity.

The relatively aggressive deliverable deadlines caused teams to come up with ways to expeditiously sort through information and make required decisions. How they collected, sifted through, interpreted, and assessed the relative importance of that information was influenced by prior decisions made in earlier stages, input received from the primary program advisor and other advisors / mentors, and (most important) their intuition and decision making rules. The teams were continually grappling with ways to sort information and orient themselves in a specific direction as a deadline loomed. Van de Ven, et al. (1999) refers to this as cycles of convergent and divergent behavior in the innovation process. The process of evaluating different alternatives between each deliverable due date was a divergent cycle of the assessment process, while each deadline and deliverable marked a period of convergence when teams had to choose a specific course of action. The divergent cycles in the process allowed and encouraged the teams to brainstorm and expand their intellectual and perceptual horizons, while the periods of

convergence caused by looming deadlines brought them back to trusted and tested decision making heuristics and the contexts in which they felt most comfortable and confident.

While the program may have a higher level of structure when compared to the level of outside pressure exerted on the typical (pre-funded) venture, the program's structure does clearly demonstrate the importance of deadlines and milestones in moving ideas and ventures forward. As the advisor noted during our interview, one of the most realistic aspects of the program is that the teams learned "you have to make decisions with far too little data," and at some point you have to say "(this is) what I know so far, and based on what I know I choose this (decision/course of action)." Entrepreneurs who fail to build in some form of structure that produces periods of convergence run the risk of paralysis by analysis in seeking the optimal opportunity. For the program participants, identifying the right opportunity was a function of the resources and knowledge available and heuristics applied at a critical decision making juncture. Similarly, the entrepreneur adopting an effectuation approach to decision making realizes that their time, money, and intellectual capital is finite and decisions must be made that effectively ration and leverage those resources (Sarasvathy, 2001).

In summary, individual expertise, knowledge, experiences, interests, motivations, and roles all significantly influenced the opportunities the teams ultimately decided to pursue. The adoption of an effectuation approach to decision-making in response to looming deadlines and major deliverables was essential to reducing the complexity of sorting through alternatives and creating a viable opportunity.

CONCLUSIONS AND DISCUSSION

Commercialization Opportunities May Be More Constructed Than Discovered

Entrepreneurs seeking to commercialize applications of potentially disruptive technologies appear to construct business opportunities that best leverage their abilities and resources within given environmental constraints. This is both a necessity due to the considerable constraints they face and a fundamentally sound strategy to reduce risk and maximize the chances for success. This approach is contrary to the concept of opportunity discovery as essentially a function of who is first to uncover or accurately define the opportunity, since theoretically actors should discover the same optimal opportunity for a given disruptive technology (Shane, 2000). The work of Shane (2000) and Van de Ven, et al. (1999) and the experiences of the program participants observed in this study demonstrate that a disruptive technology can facilitate multiple viable applications and opportunities. Each of the teams in this study evaluated a multitude of alternatives, and they eventually selected opportunities which best matched their expertise, knowledge, and decision making heuristics. The team which experienced the greatest struggle with the opportunity assessment process was hampered in part by diligently seeking the *ideal* opportunity. When this team finally viewed opportunities from a context in which they felt comfortable and knowledgeable they suddenly discovered the right opportunity for them.

Experiences, Expertise, and Motivations Shape Opportunity Construction

The prior experiences and expertise of the individual program participants influenced their ultimate choice of a specific application and market opportunity. Perceived expertise and past experiences shaped the development of decision making heuristics used in the evaluation and choice of opportunities. Differences in personal motivations for participating in the program, past experiences working in teams, willingness to take a leadership role, and relative capabilities of understanding technological concepts shaped team dynamics. Those dynamics in turn also influenced the evaluation and selection of opportunities.

Cognitive and Resource Limitations Actually Help the Opportunity Creation Process

Perhaps the most important finding from this study is that while cognitive and resource limitations have been typically framed as hindering the ability to of entrepreneurs to identify and assess a broad range of opportunities, those same limitations may actually improve the prospects of identifying a commercially viable opportunity if the entrepreneur adopts an effectuation approach to the assessment

process. It is also important to separate the process of identifying opportunities from the process of assessing them. In Shane's (2000) study, the teams did not identify or assess any opportunities that were outside of their expertise, experience, or networks. However in this study each team did identify a wide variety of unrelated opportunities. Their real challenge was attempting to assess these opportunities under significant time pressure and with limited access to specific market intelligence. The teams eventually responded to their inability to accurately predict market potential for all alternatives by focusing on those opportunities in markets in which they had some experience or expertise. Thus cognitive, resource, and time limitations compel the entrepreneur to pursue opportunities that give them the best opportunity to succeed.

Deadlines and Deliverables Also Facilitate the Opportunity Creation Process

Per Van de Ven, et al. (1999), periods of convergence are necessary to move the innovation process forward. Impending deadlines and deliverable expectations force entrepreneurs to make decisions based on incomplete information and under time frames far shorter than the time needed to process all possible courses of action and outcomes. Convergence requires entrepreneurs to rely on heuristics to effectively process and prioritize available information in making unavoidable decisions. The program teams all faced timelines that did not allow for in-depth consideration of every possible application and market alternative, nor did they have the luxury of access to all the information needed to make those assessments. The teams responded to these constraints by developing decision making rules that allowed them to best utilize available information to meet deadlines while achieving effective progress towards a viable and well defined business opportunity.

Implications for Entrepreneurs and Entrepreneurship Programs

Many aspiring entrepreneurs have at some point asked a colleague, friend, or advisor "what's a great business to get into?" The question suggests these individuals are seeking an ideal opportunity rather than creating an opportunity that would be ideal for them based on their background, interests, and resources. The prior work of Shane, Sarasvathy, Van de Ven and others, combined with the results of this study, suggest that great opportunities are created not discovered. On the one hand, both Shane and Van de Ven argue that entrepreneurs have cognition-oriented limits on their ability to identify and assess a wide range of opportunities, while Sarasvathy argues and the results of this study imply that a relatively small set of options that best leverages the entrepreneur's capabilities and resources actually enhances their ability to reduce uncertainty and improves chances for success. Constraints and capabilities compel the entrepreneur to converge on an opportunity of their construction. This suggests that both entrepreneurs and entrepreneurship programs should place a greater emphasis on assessing internal capabilities and constraints and *creating* market opportunities that best leverage those capabilities within the initial constraints. In contrast, the typical business plan process seems to emphasize the identification of significant market opportunities (in the context of the existing competitive and customer environments) and strategies for the entrepreneur to acquire sufficient resources to take advantage of the opportunity. As a result, an entrepreneur often either overstates capabilities or de-emphasizes constraints in order to present themselves more favorably in the eyes of investors – in essence, giving what they perceived to be answers investors expect rather than a true picture of the venture. While many entrepreneurs face significant resource challenges that threaten their ability to effectively compete in a market, many would be better served, especially in the early stages of venture evolution, by adopting an effectuation process that emphasized managing uncertainty through small, incremental investments and market experimentation (Sarasvathy, 2001).

It also appears that deadlines and milestones are critical to assisting entrepreneurs / teams in achieving the convergence necessary to advance opportunities and ventures. While the level of structure in the program observed in this study is higher than many entrepreneurs / teams encounter or choose to impose on themselves, there is a parallel to the staged commitments used by venture capitalists to ensure the firms they invest in are making sufficient progress. Deadlines and milestones, especially in the early stages of an opportunity and venture's evolution, encourage incremental action over prolonged analysis as

a means of gaining greater clarity on the viability of the opportunity. Therefore start-up teams and their advisors should make a conscious effort to impose and adhere to deadlines that create critical periods of convergence and move the venture forward. Similarly, programs instructing the next generation of entrepreneurs should create an environment that emphasizes the development of decision making skills under high uncertainty and aggressive deadlines. As noted earlier, some of the MBA students in the program observed in this study were initially hampered by prior training that focused on identifying optimal solutions to well-defined problems. Students of entrepreneurship must embrace ambiguity and deadline pressure because learning to operate under these conditions is essential to their development.

Limitations

A potential limitation of this study is that the subjects observed were all nascent or fledgling entrepreneurs, though the results are similar to what Shane found with more experienced teams of entrepreneurs. A potential implication of this study and the work of Shane and Sarasvathy is that nascent entrepreneurs may have a relatively limited opportunity evaluation capability due to their inexperience. This also suggests that as entrepreneurs gain experience they are able to refine their opportunity assessment process and decision-making heuristics and as result develop greater depth and confidence in their capabilities.

Upon completion of this study the author explored this possibility by conducting five (5) depth interviews with chief executives, business development officers, and marketing managers of technology firms and research laboratories in the states of Washington, Oregon, and California to discuss the keys to successfully commercializing technologies that create new markets. The respondents had been involved in multiple projects in multiple settings, from corporate to entrepreneurial start-up and research labs, in industries ranging from the life sciences to semiconductors, nanotechnology, software, and Internet services. The most significant difference between the nascent entrepreneurs in this study and experienced entrepreneurs who were interviewed was their level of confidence in identifying and successfully pursuing opportunities. For example, when relatively inexperienced entrepreneurs encountered existing market conventions or customer perceptions that seemed unfavorable to their identified opportunity, their initial reaction was to accept these existing conditions as irrevocable. In contrast, experienced entrepreneurs saw understanding latent needs as a necessary but insufficient requirement for success. They understood and accepted the need to proactively shape market conditions to their advantage. The implications for entrepreneurship programs is that while classroom instruction may build student expertise, increasing the number of experiential learning opportunities is critical to increasing their experience base and networks.

Implications for Future Research

As noted in the prior section, one promising area for additional research is examining the differences in the opportunity assessment processes of entrepreneurs based on the extent of their experience in launching ventures. Another research topic to explore further is to what extent different environmental constraints assist or hinder the opportunity assessment process. This requires comparing the opportunity assessment process across a wide variety of contexts. There is also the possibility of pedagogical research on the efficacy of opportunity assessment practices in university programs that attempt to foster technology commercialization through traditional technology transfer efforts versus a focus on the education, mentoring, and financial support of student-entrepreneurs.

This study suggests that university programs that strive to produce both commercially viable business opportunities and future technology entrepreneurs can serve as an interesting semi-natural experiment setting for observing various aspects of the commercialization process. Researchers of technology entrepreneurship often face the dilemma of either pursuing a sometimes unpredictable and time consuming process of direct observation of individual firms in situ or relying on the recollections of key informants who may be unable to recall all the subtle nuances of their experience. Observing ventures poses several challenges, the most obvious being identifying a firm at the right stage of its evolution and securing permission to observe and record its development over an extended period. In addition,

entrepreneurs face incredible stress and demands on their time during the early stages of a venture, so even after receiving approval researchers can encounter significant problems gaining consistent access and sufficient cooperation. Programs such as the one observed in this study have the potential to allow researchers to observe the early stages of venture development in a setting that offers greater reliability of access and reduces the reliance on key informant recollections.

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