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Human Capital and Search-Based Discovery: A Study of High-Tech Entrepreneurship

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What types of knowledge and experience enable those who have the desire to start a venture find an appropriate opportunity? To respond to this question, a human capital perspective is used with a sample of 166 founders of new technology ventures in university incubators. General human capital is assessed using experience depth and formal education. Specific human capital is measured using prior start-up experience as well as Shane's knowledge framework of markets, customer problems, and ways to serve markets. Findings reveal key aspects of human capital vital to explaining search-based discovery. Implications for research and entrepreneurship education are drawn.

Introduction

This study examines the knowledge and experience of new technology entrepreneurs who had been searching for an opportunity compared to those who **identified** opportunities without searching. Opportunity **identification** is a fundamental research issue in entrepreneurship research (Ardichvili, Cardozo, & Ray, 2003) and few studies offer guidance to aspiring entrepreneurs about how to search and discover opportunities (Fiet, 2007; Shook, Priem, & McGee, 2003). Discovering opportunities is strongly linked to individual characteristics and a function of both an individual's stock of knowledge (Ronstadt, 1988; Shane, 2000) and their alertness to information (Fiet; Kirzner, 1973). Thus far, the major conceptualizations of entrepreneurial opportunity subsume that entrepreneurs either search and discover opportunities or create opportunities without a deliberate search (e.g., Alvarez & Barney, 2007; Bhave, 1994; Lumpkin, Hills, & Shrader, 2004). For the purposes of the present study, search-based discovery is defined as when the desire to start a venture precedes discovery, thus individuals search to find an appropriate opportunity. Shook et al. reviewed the literature on enterprising individuals and opportunity discovery and concluded that despite the obvious importance and

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some promising findings, relatively little empirical research investigates how the effects of education or experience link to search-based discovery. They called for future studies to examine the conditions in which potential entrepreneurs actively search and discover opportunities compared to when entrepreneurs **create** opportunities. Although advocates of search-based discovery and opportunity creation without search describe individual knowledge or expertise as critical to the process (Fiet; Sarasvathy, 2008), very little is known about how individuals wishing to start ventures can leverage knowledge and identify opportunities. Thus, the goal of this study is to provide actionable advice about how entrepreneurs discover opportunities through knowledge resources to inform educational initiatives wishing to empower individuals searching to discover opportunities.

To assess what types of knowledge and experience are associated with effective search-based discovery, the lens of human capital is used. Human capital theory was originally developed to study the economic value of education (Becker, 1964; Schultz, 1960) and indicates that people possess varying skills, knowledge, and experience that have economic value. An individual can invest in education and experience, and one's outputs depend partly on the rate of return on the human capital one possesses. Consistent with Becker, entrepreneurship scholars often distinguish between specific and general types of human capital (e.g., Corbett, 2007; Dimov & Shepherd, 2005; Ucbasaran, Westhead, & Wright, 2008; Zarutskie, 2010). Specific human capital refers to skills or knowledge that is useful to a particular setting or industry, whereas general human capital, such as literacy or formal education, is useful to a great variety of employers (Wiklund & Shepherd, 2003).

The human capital approach has guided studies on multiple aspects of entrepreneurial behavior. For example, human capital has been shown to facilitate nascent entrepreneurship (Davidsson & Honig, 2003), fund performance of venture capitalists (Dimov & Shepherd, 2005; Zarutskie, 2010), the number of opportunities entrepreneurs identify (Corbett, 2007; Ucbasaran et al., 2008), and venture survival (Bosma, Van Praag, Thurik, & de Wit, 2004; Gimeno, Folta, Cooper, & Woo, 1997). However, there is little evidence of the linkages among human capital and effective search-based discovery, thus representing a gap in the literature. This research gap is the focus of the current study, which seeks to make the following contributions. First, to investigate how aspects of knowledge and experience link to search-based discovery, this study draws on prior research that examines both general and specific types of human capital. Technology entrepreneurs' general human capital is investigated using both formal education and depth of experience. Second, this study increases our understanding of the specific types of human capital that link to search-based discovery using previous start-up experience as well as Shane's (2000) prior knowledge framework. Using an embedded case study approach, Shane examined the commercialization of a single patented technology by different entrepreneurs and showed that individual knowledge of existing markets, ways to serve that market, and knowledge about customer problems influence the opportunities one can discover. He found that each entrepreneur unanimously attributed their particular venture opportunity to the possession of these specific types of prior knowledge. Shook et al. (2003) called for future studies to test the generalizability of Shane's findings and to explore whether the aspects of prior knowledge identified are of equal importance to individuals' searching to discover an opportunity compared to those who identify opportunities without search. The current study contributes by responding to this call using a sample of technology entrepreneurs operating in university incubators. In sum, this research **demonstrates** how differences in individual human capital systematically influence effective search-based discovery in the high-technology context.

In what follows, the dominant conceptualization of entrepreneurial discovery is reviewed. Then, key aspects of general and specific human capital are discussed and hypotheses developed. Next, the procedure is outlined and the results of an empirical undertaking of start-ups in university incubators are reported. A discussion follows and the study concludes with implications for research and entrepreneurship education.

Views of Opportunity and Search-Based Discovery

Theories of entrepreneurial opportunity reflect an assumption that entrepreneurs either search to discover opportunities or create opportunities without searching. Alvarez and Barney (2007) recently described these views as discovery theory and creation theory. The discovery view is predominantly about searching the environment for competitive imperfections brought about by environmental changes (Edelman & Yli-Renko, 2010) while opportunity creation indicates that opportunities do not necessarily evolve out of preexisting industries or markets. The creation theory assumes it is the entrepreneur's **actions** that result in opportunities and cannot be known ex ante (Alvarez & Barney). Therefore, entrepreneurs do not search to find opportunities; they act and observe how consumers and markets respond to their actions as opportunities are social constructions that do not exist independent of the entrepreneur's perceptions (Aldrich & Kenworthy, 1999). In contrast, the discovery theory assumes competitive imperfections result in opportunities that come about exogenously from changes in technology, society, regulatory, or the political environment. Since opportunities are created by exogenous changes to an industry or market and since these opportunities are objective and observable, then individuals associated with an industry or market should be aware of any opportunities a change has created. However, if everyone associated with a particular industry or market knew about the opportunities, and were all equally skilled to exploit these opportunities, then they could all try to exploit them. Therefore, entrepreneurs who discover opportunities are different from others in their ability to either see or exploit opportunities (Alvarez & Barney). Among the key factors in which individuals may vary from one another is their alertness (Fiet, 2007; Kirzner, 1973) and idiosyncratic **knowledge** (Fiet; Shane, 2000).

Kirzner (1979, p. 48) defined alertness as to "notice without search." However, he later extended this definition to "a motivated propensity of man to formulate an image of the future" (Kirzner, 1985, p. 56). Kirzner's alertness perspective has been criticized because although it may describe how some entrepreneurs make discoveries, it offers virtually no guidance to aspiring entrepreneurs other than to stay alert (Fiet, 2007). Demsetz (1983) and Fiet (2002) argued that if alertness is the key to opportunity discovery a more familiar name for it is luck—which we do not know how to teach. Fiet developed an alternate perspective that emphasizes alertness while restricting and maximizing search outcomes based on repeatedly successful entrepreneurs. His grounded theory approach indicates entrepreneurs may access signals while not searching or by conducting a targeted systematic search based on alertness to promising information channels which reflect their specific knowledge. In contrast to Kirzner's view, an information channel approach requires alertness to information within a particular and **known domain**. In addition to alertness, idiosyncratic **knowledge** is important to opportunity discovery. Information about industries or markets cannot be known in totality by any individual as each person's accumulation of knowledge and experience is idiosyncratic (Ronstadt, 1988). To discover an opportunity, it is important that the entrepreneurs have specific knowledge and information associated with an opportunity (Fiet; Shane, 2000). Fiet argues that entrepreneurs can identify **more** discoveries and discoveries with **greater**

wealth-creating potential by searching known information channels. However, very little is known about where these information channels exist **or how specific knowledge** systematically relates to search-based discovery. This is surprising considering the growing theoretic emphasis on human capital as important to opportunity identification and innovation creation (Dakhli & De Clercq, 2004; Ucbasaran et al., 2008).

Human Capital and High-Tech Opportunities

Becker (1964) extended human capital theory based on the use of microeconomic principles to explain a wide range of human behavior in market systems and reconceptualized factors such as education, experience, and job training into virtual investments. That is, they were recast as resources like equipment, technology, or other strategic enablers. Although entrepreneurship research has examined behavioral propensities (Mosakowski, 1998) and personality traits (Zhao & Seibert, 2006) human capital is less person-centric. Unlike traits, human capital is transferable and individuals can consciously invest in and acquire knowledge and experience (Ucbasaran et al., 2008). Learning-by-doing and experientially acquired human capital is well recognized in the literature as individuals learn from experience just as some knowledge can be acquired from observation (Arrow, 1962; Minniti & Bygrave, 2001).

Opportunity discovery is based on the observation that cognitive aspects such as prior knowledge and bounded rationality constrain effective search just as the same cognitive barriers shape a theory of what can be known and how to search for it (Fiet, 1996, 2007). This is partially due to an entrepreneur's absorptive capacity, which refers to one's ability to recognize, value, assimilate, and apply knowledge needed to achieve commercial ends (Cohen & Levinthal, 1990). According to research on absorptive capacity, a lack of knowledge in an area may preclude an individual from effectively acquiring subsequent knowledge, which may differentiate their competence to discover and exploit an opportunity. Thus, prior knowledge is important because it circumscribes the domain or boundary conditions within which an individual may search **and acquire new knowledge**. Prior knowledge and experience are the sources of most discoveries because they require minimal acquisition of new knowledge (Venkataraman, 1997). For instance, most venture ideas come from past employment experience (Bhide, 2000) and suggests that some types of knowledge may be of unequal value to individuals searching to discover opportunity. To explore this notion, a model is developed comprised of general and specific human capital in the following section.

General Human Capital Hypotheses Development

Previous research shows that general human capital is an important aspect of identifying opportunities (Davidsson & Honig, 2003; Ucbasaran et al., 2008) although search-based discovery is not as well understood. Experience and education are the characteristics most central to the concept of human capital (Becker, 1964). Experience includes professional work activities and the practical learning incurred during nonformal educational activities such as job training. Experience in labor markets and management positions have been shown to lead to better venture performance in terms of survival, profit, and employment growth (Bosma et al., 2004; Gimeno et al., 1997; Robinson & Sexton, 1994). Education, another key aspect of general human capital, increases a person's general stock of information and skills, including the ones needed to identify an

opportunity. For example, Baum, Locke, and Smith (2001) examined the performance of biotechnology firms and showed that founders with master's degrees or higher had faster employment and revenue growth. Numerous studies of human capital assume that "more is better" and operationalize human capital with formal education or years of schooling (Bruderl, Preisendorfer, & Ziegler, 1992; Gimeno et al.; Wiklund & Shepherd, 2003, 2008). For example, Robinson and Sexton (1994) examined census data and found education increased the likelihood of self-employment. Similarly, Ucbasaran et al. found that general human capital increased the number of opportunities identified. However, these may be unintended discoveries rather than search-based. A possibility is the greater a person's education, the more likely to recognize pertinent information and identity, or create an opportunity without initially having planned. Becker showed that as people invest in human capital, their earnings increase. If a person is highly invested in their own general human capital (i.e., experience depth and formal education), then the more likely they can earn satisfactory wages. Consequently, individuals heavily invested in formal education and professional experience may be less likely to search for an entrepreneurial opportunity. The wage and risk considerations of owning a business will likely be considered unattractive given their alternatives. Consequently, high investments in general human capital will likely be negatively related to search-based discovery.

Hypothesis 1a: General experience depth is negatively related to search-based discovery.

Hypothesis 1b: General formal education is negatively related to search-based discovery.

In sum, it is argued that technology entrepreneurs who have greater general human capital will be less likely to search to discover opportunities. However, the approach of using general human capital alone has been criticized because of a lack of sensitivity in these conceptually broad empirical measures (Dimov & Shepherd, 2005). Entrepreneurship research on more specific types of human capital shows promise in deepening our understanding of opportunity discovery (Fiet, 2007; Shane, 2000).

Specific Human Capital and Hypotheses Development

Studies of specific human capital essentially view opportunity **identification** as a problem-solving process that utilizes particular kinds of knowledge and experience. These kinds of specific human capital can be divergent and lead to new product and service developments (O'Connor & Veryzer, 2001). Some types of knowledge and experience have been shown to be especially germane to discovery and venture creation. For example, Shane (2000) delineated three dimensions of prior knowledge required to **discover** opportunities in the high-technology context: prior knowledge of markets, ways to serve markets, and customer problems.

Prior knowledge of markets entails possessing information about how a particular market operates. Von Hippel (1988) indicated that such prior knowledge includes relationships with suppliers and customers as well as information about effective sales techniques and capital requirements. Prior industrial knowledge about how products or technologies influence a market can also enable one to identify an entrepreneurial opportunity (Roberts, 1991). Though market knowledge is not always known publicly, it can be acquired explicitly or inferred tacitly through experience as a manufacturer, supplier, employee, or customer. Knowledge of markets is a well-known source of opportunity, and therefore, persons who search for opportunities are likely to acquire knowledge of markets.

Hypothesis 2a: Prior knowledge of a particular market is positively related to search-based discovery.

Prior knowledge of ways to serve markets includes information about how a technology can be developed or packaged as a product or service that satisfies consumer needs. Aldrich and Wiedenmayer (1993) showed that the product and service lines entrepreneurs establish frequently include organizations in which they were previously employed. In addition, entrepreneurs tend to recognize opportunities that subsume their prior experiences. For example, an entrepreneur with experience in machine design is more likely to package a technology in a way that is germane to some kind of machine than a service. Other entrepreneurs might instead recognize service opportunities due to lack of knowledge about machine design and manufacturing but a high level of knowledge about a particular service industry. By the same token, an entrepreneur with pharmaceutical experience would likely be inclined to package a technology in a way that meets U.S. Food and Drug Administration standards in order to fulfill some medicinal or lifestyle need (Shane, 2000). Greater knowledge of ways to develop products leads one to search for an opportunity to improve upon existing solutions.

Hypothesis 2b: Prior knowledge of ways to serve a particular market is positively related to search-based discovery.

Prior knowledge of customer problems is information about what customers need and want. The locus of innovation often lies with users even though they cannot easily articulate their needs for undeveloped solutions (Von Hippel, 1988). The missing piece of the puzzle for these kinds of opportunities is the solution offered by the entrepreneur. Indeed, a solid understanding of user needs is essential to such opportunities, as a lack of familiarity with customer problems makes it difficult to identify workable solutions (Roberts, 1991). Thus, entrepreneurs frequently undertake new ventures to solve customer problems they incurred in their own experiences (Von Hippel). For example, experience working with clinical pharmacology customer problems can lead an entrepreneur to recognize an opportunity to apply technology for the treatment of hypertension (Shane, 2000). Von Hippel (1986) emphasized the importance of learning from lead users as a means to develop novel products. Lead users of products and services usually understand marketplace needs far in advance of other market actors. Thus, the market opportunities they perceive may be valuable but not generally obvious. Prior knowledge of customer problems leads to searching for opportunities to solve them.

Hypothesis 2c: Prior knowledge of specific customer problems is positively related to search-based discovery.

The most frequently investigated aspect of specific human capital in entrepreneurship research is prior start-up experience (Davidsson & Honig, 2003; Dyke, Fischer, & Reuber, 1992; Wiklund & Shepherd, 2008). For example, in a study of technology entrepreneurship, Stuart and Abetti (1990) found that founder's experience in previous start-ups positively affected early venture performance. Minniti and Bygrave (2001) theorized that entrepreneurs will repeat only those choices that appear most promising and discard the ones that resulted in failure. Both success and failure in the process of venture creation facilitates learning that can benefit individuals in future entrepreneurial endeavors. Supporting this view, Ucbasaran et al. (2008) found that owners of private firms who had previous business ownership experience were more likely to identify a greater number of business opportunities although the mode in which they were identified (i.e., search versus nonsearch) was not explored. Fiet (2007) discussed the concept

of systematic search based on entrepreneurs who had been repeatedly successful in creating new ventures. In his view, effective search techniques can be gleaned from entrepreneurs who have already identified opportunities successfully. Based on data from serial entrepreneurs, Fiet reports that entrepreneurs with previous entrepreneurial experience will search more effectively based on their specific prior knowledge, experience, and promising information channels.

Hypothesis 2d: Prior start-up experience is positively related to search-based discovery.

Methodology

Sample

To procure a sample of entrepreneurs who had recently founded high-technology ventures, university-affiliated technology incubators were contacted. Technology incubators provide physical space and business support to accelerate the development of technology ventures via an array of resources and services. An incubator's goal is to produce successful ventures that will leave the incubator financially viable and free-standing. A list of incubators in the United States was obtained from the National Business Incubation Association online database. Incubators were selected for the study based on proximity to a large research university in the Midwestern United States and the number of housed ventures. All of the incubators were affiliated with universities and their representative technology transfer offices. In total, 15 incubators participated and afforded individual meetings with venture founders. Surveys were completed during these meetings. The total sample consisted of 166 founders of new technology ventures. Of the respondents, 93% were male and 7% female. The average level of professional experience was 19.22 years and the average number of employers the entrepreneur had previously worked for was 3.92. Education level broke down in categories of 35% with doctoral degrees, 26% with master's degrees, 34% with bachelor's degrees, 2% with associate's degrees, and 3% with only high school diplomas. The represented industries of the ventures included 51% in information technology, 20% in instrumentation or diagnostics, 10% in industrial products or materials, 7% in biotechnology, 7% in energy, and 5% in other consulting or research and development. Of the ventures included, 59% offered products or mostly products compared to 41% that indicated they were primarily services oriented.

Data Collection Procedure

Incubator managers were identified and contacted via telephone. The manager was given an overview of the research initiative and asked to provide contact information for founders of technology-based ventures approximately 5 years old or younger. In all cases, the manager provided the names and contact information as requested. The technology entrepreneurs were then contacted and asked to participate in a research project funded by the Kauffman Foundation and the sponsoring university. Participants were informed that the results of the study may be used to improve entrepreneurship education. The entrepreneur was questioned to ensure they were indeed responsible for the venture idea. Entrepreneurs reporting they were not responsible for the venture idea were not surveyed. If the contact person was responsible for the venture idea, a meeting was scheduled during

which a survey was completed. Of the entrepreneurs contacted, one elected not to participate and 10 were unable to meet due to meeting conflicts such as prearranged travel plans.

Measures

Search-based discovery was measured with an item with three response options to assess the type of discovery. This item was derived from the Panel Study of Entrepreneurial Dynamics (Gartner, Shaver, Carter, & Reynolds, 2004) and asked if the entrepreneur had desired to find a business opportunity first or whether the business idea came first without search. Response categories included: (1) business idea or opportunity came first; (2) desire to start a business came first; or (3) idea and desire to have a business occurred simultaneously. To tap the construct of interest, responses that indicated they had the desire to start a business first were coded as a 1 and all other responses were coded as 0.

General human capital was assessed using two items. One asked about experience depth and the other measured education level. Depth of experience was operationalized with an open-ended item requesting the number of years of professional work experience. Years of work experience has been widely used by numerous human capital studies (e.g., Bosma et al., 2004; Davidsson & Honig, 2003; Evans & Leighton, 1989; Marvel & Lumpkin, 2007). The education item used an ordinal scale and indicated highest level of education. The levels included high school, associate's, bachelor's, master's, and doctoral degrees. Following Wiklund and Shepherd (2003, 2008), the responses were coded into years of education. Years of education has also been commonly used in general human capital research (e.g., Davidsson & Honig; Gimeno et al., 1997; Ucbasaran et al., 2008; Wiklund & Shepherd).

Specific human capital was measured using scales developed from Shane's (2000) three prior knowledge types and previous start-up experience. These include (1) prior knowledge of ways to serve markets; (2) prior knowledge of customer problems; (3) prior knowledge of markets; and (4) prior start-up experience. The prior start-up experience variable was assessed using an open-ended item. The item asked respondents to indicate the number of times they had participated in starting a venture prior to the current one. Previous start-up experience has received considerable attention in the entrepreneurship literature, and other studies include a similar item (e.g., Bosma et al., 2004; Ucbasaran et al., 2008; Wiklund & Shepherd, 2008).

The prior knowledge types were assessed using Marvel and Lumpkin's (2007) prior knowledge scales. Each prior knowledge construct has four items that address the entrepreneur's knowledge when they discovered their venture opportunity. After each prior knowledge item, two Likert-type response scales were included, one that addressed the amount of prior knowledge and a second that inquired about its importance to perceiving the opportunity. Opportunity discovery was assumed to be a function of both a person's stock of knowledge (Ronstadt, 1988; Shane, 2000) and a person's alertness (Fiet, 2007; Kirzner, 1973) to that knowledge. The **amount** (*A*) and **importance** (*I*) response scores were weighted by multiplying the two scores for each item together. The weighted scores for each prior knowledge type were then summed and resulted in a prior knowledge variable score (*P*).

$$P = \sum_{i=1}^{n} A_i I_i$$

Table 1

Factor Structure of Prior Knowledge Items

Item	Ways to serve markets	Customer problems	Markets
My hands-on experiences in creating products/services similar to my forthcoming business.	.80		
My knowledge of ways to produce products/services similar to that of my forthcoming product/service.	.79		
My knowledge of products/services similar to that of my forthcoming business.	.61		
My knowledge of specific standards that my forthcoming product/service would need to meet.	.58		
My knowledge of different customers' problems that my forthcoming business could help with.		.75	
My knowledge of ways customers use products/services similar to that of my forthcoming business.		.68	
My first-hand interactions with customers similar to that of my forthcoming business.		.67	
My knowledge of lead customers similar to that of my forthcoming business.		.64	
My knowledge of suppliers in the primary market of my forthcoming business.			.83
My knowledge of manufacturers or developers in the primary market of my forthcoming business.			.80
My knowledge about the market of my forthcoming business not known to the general public.			.74
My knowledge about how the market functions of my forthcoming business.			.57
Amount scale Cronbach's alpha	.80	.84	.83
Importance scale Cronbach's alpha	.71	.70	.81

A principal components factor analysis of prior knowledge items was undertaken to assess factor structure and psychometric properties of the items. Following standard procedures (Hinkin, 1995), four items each contributed to an orthogonal principal component with loadings exceeding .40. Based on loadings and eigenvalue cutoffs of 1.0, the items were retained to constitute the scale dimensions. The amount and perceived importance scores were reliable, with Cronbach's alpha coefficients ranging from .70 to .84 (Table 1).

Results

Table 2 presents the intercorrelations and descriptive statistics for all study variables. Results showed that all multicollinearity estimates among the independent variables were well within acceptable ranges (Hair, Anderson, Tatham, & Black, 1998). Entrepreneurial discovery mode was search-based for 52 cases and non-search-based for 112 cases.

To determine if differences in human capital exist among those who search versus those who did not set out to start a business, *t*-tests were executed. The results appear in Table 3. The general human capital means for both experience depth and formal education were significantly different ($p < .05$) between groups. Both the means for experience

Table 2

Descriptive Statistics and Variable Intercorrelations

Variables	Mean	SD	1	2	3	4	5	6
1. Search-based discovery	.31	.47						
2. Experience depth	19.22	10.24	−.15					
3. Formal education	18.77	3.31	−.17*	.18*				
4. Ways to serve markets	33.79	14.69	.16	.05	−.21**			
5. Customer problems	32.62	13.38	−.10	−.02	−.15	.57**		
6. Markets	25.43	12.31	−.04	.10	−.19*	.41**	.60**	
7. Start-up experience	.91	1.20	.12	.22**	.02	−.08	−.11	−.06

* $p < .05$, ** $p < 01$
SD, standard deviation.

Table 3

Human Capital Mean Comparisons by Discovery Mode

	Search-based (means)	Non-search (means)	N	*t*-test
General human capital				
Experience depth	16.86	20.18	163	−2.13*
Formal education	17.92	19.09	163	−2.06*
Specific human capital				
Ways to serve markets	37.10	32.19	157	2.02*
Customer problems	30.60	33.56	157	−1.35
Markets	24.71	25.75	155	−.49
Start-up experience	1.13	.82	163	1.45†

† $p < .10$, * $p < .05$

depth and formal education reported were lower for those entrepreneurs who reported effective search-based discovery compared to the non-search group. Of the specific human capital variables, ways to serve markets was significant ($p < .05$) and prior start-up experience was marginally significant ($p < .10$). Entrepreneurs who effectively searched to discover an opportunity had greater prior knowledge of ways to serve markets and more start-up experience.

Logistic regression analysis was used to examine the combinations of human capital that forecast effective search-based discovery. This approach provides the probability of selecting those who effectively searched to discover and exploit an opportunity from the entire sample of technology entrepreneurs. The goodness of fit chi-square tests the null hypothesis that the coefficients for the terms in the model, except the constant, are zero. The model regressed search-based discovery on the human capital variables. Table 4 shows the results. The χ^2 and log likelihood indices associated with the change in variance explained were significant ($p < .01$).

Table 4

Logistic Regression Results for Human Capital and Search-Based Discovery

	Search-based discovery
General human capital	
Experience depth	−.05* (.02)
Formal education	−.05 (.06)
Specific human capital	
Ways to serve markets	.05** (.02)
Customer problems	.05* (.02)
Markets	−.00 (.02)
Start-up experience	.36* (.17)
−2 log likelihood	164.06
Model's χ^2	19.39**
Df	6
Overall hit rate	72.3%
Nagelkerke r^2	.18
N	148

* $p < .05$, ** $p < .01$
df, degree of freedom.

For general human capital, experience depth had a significant and negative relationship to search-based discovery, thus offering support for hypothesis 1a. Formal education was not statistically significant in the variance explained. Therefore, hypothesis 1b is not supported.

Among the specific human capital variables, prior knowledge of ways to serve markets explained a significant portion of variance ($p < .01$) and was positively associated with search-based discovery. Prior knowledge of customer problems, as well as prior start-up experience, was also significant in the variance explained ($p < .05$) and positively associated with search-based discovery. Prior knowledge of markets did not explain a significant portion of variance in the discovery variable. Hence, of the specific human capital hypotheses, hypotheses 2a, 2b, and 2d were supported.

Discussion

This study delineated relations between aspects of human capital and search-based discovery in the high-technology context. The findings support and extend existing human capital research related to entrepreneurial opportunity and innovation creation (Marvel & Lumpkin, 2007; Shane, 2000). In particular, the study shows that both general and specific human capital are useful to explaining the mode in which opportunities are realized.

Experience depth was negatively related to search-based discovery ($p < .01$). That is, the **less** professional experience a person has, the greater the likelihood they will effectively search to discover and exploit an opportunity. Entrepreneurs with a greater amount of professional work experience appear less likely to search for opportunities—they just come across them accidentally. This supports the view that deep experience provides cues

that allow entrepreneurs to see compelling opportunities even when not actively searching for them. Although formal education was not significant in the variance explained in the discovery variable, entrepreneurs who searched for opportunities tended to have less education than those who did not search for an opportunity. Those entrepreneurs who searched to find venture opportunities tended to have bachelor's and master's degrees as their highest level of formal education. On the other hand, the entrepreneurs whose business idea came to them without first having the desire to start a business tended to have higher levels of formal education such as doctorate's. This supports the view that individuals more heavily invested in experience and education are less likely to search for an entrepreneurial opportunity.

Prior knowledge of ways to serve markets explained a significant portion of variance in the discovery variable and was positively associated with effective search-based discovery ($p < .01$). This suggests that knowing how to develop or package existing technologies as products or services is critical to searching to find an appropriate opportunity. An explanation may be that persons with knowledge of how to develop or package solutions to meet customer needs lead one to search and improve upon known existing solutions. If an individual knows how to create products that solve customer problems, they tend to search to find opportunities to improve on existing offerings. Prior knowledge of customer problems also explained a significant portion of variance and was positively associated with effective search-based discovery ($p < .05$). This suggests that knowledge of customer problems leads to searching to discover opportunities to solve them. Another key finding was previous start-up experience raises the likelihood that an entrepreneur will search and find opportunities in the future ($p < .05$). The entrepreneurs in the sample with previous start-up experience tended to seek out new opportunities and not discover them without first having the desire to start another business. It seems once a person has been engaged in the entrepreneurial context, they have a propensity to seek to start a venture. This supports Fiet's (2007) view that once a person gains experience in creating new ventures, they will systematically search again. The findings of this study provide support for Fiet's assertion that specific types of knowledge are of particular importance to search-based discovery and more so than general types of knowledge. Those entrepreneurs who searched to discover opportunities appear to have been successful in their goal of venture creation partially because of searching an information channel that was already known to them. That is, they increased their odds of success by searching a promising and restricted domain. Overall, the specific areas of prior knowledge identified by Shane (2000) appear to serve as promising information channels that facilitate search-based discovery.

The findings also provide some insights relative to research on opportunity creation. Indeed, the majority of technology entrepreneurs examined here did not first have the desire to start a business—the opportunity just came to them without searching. Creation theory asserts that instead of searching, entrepreneurs create subjectively constructed opportunities through iterative learning processes (Alvarez & Barney, 2007). Although the focus here was search-based discovery, the results show that opportunities that came about without a search were identified or developed by entrepreneurs with statistically more years of experience and deeper levels of formal education, such as a doctorate degree. Of the aspects of human capital studied here, experience depth best explains how opportunities emerge into existence without a search. Of particular note, Ucbasaran et al. (2008, p. 157) argued that individuals with greater general and specific human capital have "more ingredients" to work with relative to **both** opportunity discovery and opportunity creation. However, the findings here run counter to their assertion. Instead, findings suggest extensive levels of formal education and many years of experience hint at a deeper understanding of opportunity **creation** in the high-tech context.

Implications for Entrepreneurship Education

Perhaps among the greatest challenges in entrepreneurship education is how best to prepare students who have the desire to be an entrepreneur to discover and exploit an opportunity when they see it. In a study of senior-level undergraduate business students, DeTienne and Chandler (2004) found evidence that creativity training influenced the ability to generate a greater number of ideas and more innovative ideas. Following their lead, this study provides support that the ability to discover an opportunity can be facilitated through educational initiatives as aspiring individuals can consciously invest in new knowledge and experience. Just as students acquire explicit knowledge as part of formal education efforts, learning by doing, and experientially acquired human capital is widely accepted (Arrow, 1962; Jovanovic & Nyarko, 1995; Minniti & Bygrave, 2001). This study provides guidance for educators faced with the challenge of preparing students wishing to start a venture. Aspiring students who possess relevant specific knowledge will have a comparative advantage in discovering high-potential venture opportunities (Fiet, 1996, 2007). The study findings provide insights about the types of specific knowledge that may be especially beneficial. Three specific types of human capital appear most beneficial for those who have the desire to discover an opportunity: (1) prior knowledge of ways to serve markets; (2) prior knowledge of customer problems; and (3) prior experience within start-ups. Knowledge of ways to serve markets is how a technology or technologies can be developed or packaged as a product or service offering that satisfies consumer needs. Indeed, other studies have shown that the product or services new entrepreneurs introduce are similar to where they were previously employed (Aldrich & Wiedenmayer, 1993). A person who has knowledge or experience of how to create a particular product or service offering is more likely to do so again. For example, individuals with experience in machine design are more likely to package a technology as a product rather than a service. Academic pedagogy, as well as experience, plays a role in developing this knowledge. Second, prior knowledge of customer problems appears to enhance effective search-based discovery. The locus of innovation often lies with users even though they cannot easily articulate their needs for undeveloped solutions (Von Hippel, 1988). Integrated projects whereby students learn about specific customer problems and develop proactive solutions may enhance entrepreneurship education efforts. A third implication is developing education programs with integrated learning opportunities within start-ups. In this study, the experience acquired from working with other new ventures promoted the likelihood of searching and exploiting future opportunities. As an increasing number of universities are creating incubators to spur economic development and technology transfer, these may also provide an opportunity for a more holistic approach to entrepreneurship education. For example, students may engage in project-based efforts as part of course or program requirements or through internships within technology starts-ups to acquire applied experience in serving particular markets or helping solve customer problems. Further, if aspiring students have the desire to start a business in a particular industry setting, such as information technology, acquiring experience in incubator firms in a similar industry may enhance information channels and search-based discovery. For example, Bailey and Helfat (2003) observed that an individual's industry-related human capital can be transferred outside of an industry to other industries that make related products or that utilize related resources and production processes.

Limitations and Future Research

The study findings are best regarded in light of some limitations. First, technology entrepreneurs with incubator-housed ventures in the Midwestern United States

constitute a focused sample. Therefore, the results may not generalize to entrepreneurs operating without the support of an incubator, or those operating in incubators in other locations. Further, as entrepreneurs do leave incubators once their ventures fail, it is possible that a mild selection bias was present in the data set. Second, the data collection procedure called for entrepreneurs to recall broad aspects of knowledge at a point in time in the past. Such recall tends to be specious, but can be of greater fidelity when the collection is related to major life events (Huber & Power, 1985). Based on the meeting during which the survey was completed, it was clear that the entrepreneurs were recalling major life events: identification of the opportunity for their venture. Yet, the cognitive and psychological limitations warrant a degree of caution when interpreting the findings.

The current study contributes to examinations of human capital and opportunity identification but further research is needed. Studies of opportunity identification have drawn on samples of students (e.g., DeTienne & Chandler, 2004), owners of private firms (Ucbasaran et al., 2008), and technology professionals (Corbett, 2007) among others but evidence suggests that entrepreneurs frame problems in different ways compared to students (Dew, Read, Sarasvathy, & Wiltbank, 2009) highlighting the need for future studies to explore how varying samples identify opportunities and what explains these differences. In terms of context, very few studies using a human capital perspective or those focusing on opportunity identification do so in the high-tech context. This is surprising considering the high-tech setting is highly appropriate for examining aspects of knowledge as well as entrepreneurial opportunity (Corbett). Future studies could benefit from exploring opportunity identification in the high-tech corporate entrepreneurship context and other knowledge-intensive settings. Another area of promising future research appears to be specific types of human capital and the linkages to opportunity identification and other entrepreneurial outcomes. Finer-grained measures of knowledge like those employed here, using domains or dimensions of knowledge, have been encouraged (Short, Ketchen, Shook, & Ireland, 2010) and the findings suggest there is much more to learn from a multidimensional view of knowledge. For example, the knowledge constructs identified by Shane (2000) and employed here may be of unequal importance to learning within venture development, innovation creation, and generating sales or employment. Finally, there is little doubt the process of discovery is multifaceted involving layers of complexity and mediating variables may play a role. This empirical undertaking has been limited to direct effects although future research is encouraged to explore other models and constructs that explain how aspiring individuals can search and discover, or create, entrepreneurial opportunities.

Conclusion

This study contributes to one of the most important questions facing entrepreneurship research today: What types of knowledge and experience enable those who have the desire to start a venture to find an appropriate opportunity? This study responded directly to this fundamental question and demonstrated how the lens of human capital may provide actionable advice to entrepreneurship education initiatives. Findings underscore and illustrate the importance of human capital and how it links to effective search-based discovery.

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