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The Role of Human Capital in Technological Entrepreneurship

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This special issue addresses the role that the human capital characteristics of individuals and teams play in the complex process of technological entrepreneurship. In this article, we position the special issue on human capital and technology-based entrepreneurship within the literatures concerning academic entrepreneurship, technology transfer and innovation, and corporate spin-offs. We summarize the articles in the special issue and also outline a research agenda at the firm, entrepreneurial team, and individual entrepreneur levels. Finally, we discuss managerial and policy implications.

Introduction

In recent years, there has been a substantial increase in the use of technology commercialization as a platform for creating new ventures. The process of forming new technology-based ventures often involves interaction between a vast array of agents, both from the private and public sectors. Examples include university technology transfer officers, scientists and engineers, corporate executives, and independent entrepreneurs. Unfortunately, little is known regarding how these and other individuals and teams impact the effectiveness through which technology-based ventures are created and subsequently grown. This special issue seeks to address the role that the human capital characteristics of individuals and teams play in this complex process.

Human capital comprises the stock of knowledge and skills that resides within individuals (Becker, 1964). Further, human capital can be developed over time and transferred between individuals. This differentiates human capital from other individual characteristics, such as personality traits, which to date have been found to have a less certain impact on entrepreneurial outcomes. Our interest in technology centers on the use of scientific knowledge to bring to the world value-creating innovations. Technological innovation has long been viewed as an integral part of entrepreneurship (Drucker, 1985),

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and the individual as its primary driving force (Schumpeter, 1934). Therefore, this special issue touches upon the most critical inputs and outcomes of entrepreneurship.

It is natural to study the relationship between human capital and technological entrepreneurship. Many theoretical and empirical studies in economics have demonstrated the importance of knowledge and experience in enabling firms to successfully implement and adapt to changes in technology (Bartel & Lichtenberg, 1987, 1990; Siegel, 1999; Siegel, Waldman, & Youngdahl, 1997). These articles share in common an underlying assumption, based on human capital theory, that employees with more human capital (in the form of education and experience) are more productive than comparable employees in high-technology, entrepreneurial firms and industries. Such employees are highly useful to high-technology, entrepreneurial firms because they have a greater ability to solve problems extemporaneously and to fluidly adapt to changes in the external environment.

The rise of the knowledge-based economy, along with the rapid increase in university technology commercialization and entrepreneurship, has led to a series of special issues of leading journals in management and economics on various aspects of technological entrepreneurship. These special issues have been characterized by a wide variety of disciplinary perspectives and numerous levels of analysis (e.g., scientists, firms, universities, incubators, science parks, regions, and nations). Some special issues have considered the societal and organizational factors relating to technological entrepreneurship and academic entrepreneurship in particular (e.g., Markman, Siegel, & Wright, 2008; Siegel, Thursby, Thursby, & Ziedonis, 2001; Siegel, Wright, & Lockett, 2007). Other special issues have focused on aspects relating to geography, specifically with respect to science parks and incubators (Phan, Siegel, & Wright, 2005). In addition, special issues have focused on university-based technology transfer with an emphasis on licensing and patenting rather than new venture creation (Link & Siegel, 2005; Link, Scott, & Siegel, 2003; Siegel & van Pottelsberghe, 2003) and on intellectual property in general (Siegel & Wright, 2007). There has also been examination of scientific and technical human capital more generally (Bozeman & Mangematin, 2004).

Several special issues have focused specifically on technological entrepreneurship (Mowery & Shane, 2002; Shane & Venkataraman, 2003; Phan & Foo, 2004). For instance, the *Journal of Technology Transfer* special issue on "Entrepreneurship and Technology Transfer" (Wright, Birley, & Mosey, 2004) focused on enhancing understanding of the wealth-creating aspects of university start-up companies and particularly those created on the basis of technology developed in universities. The editors noted that there was little evidence on the nature of the entrepreneurs in these ventures. The *Research Policy* special issue on "The Creation of Spin-Off Firms at Public Research Institutions" (Lockett, Siegel, Wright, & Ensley, 2005) drew attention to the knowledge gap between the technology created in universities and the requirements for the commercial exploitation of that knowledge. Across all these special issues there has, however, been relatively little attention to the role of human capital. The current special issue extends this conversation on technological entrepreneurship by reaffirming the central role that individuals and teams play as the driving forces behind the development and growth of technology-based ventures.

In general, the role of individuals and teams has recently made a reemergence as a critical component in the study of entrepreneurship (Baron, 2002; Ensley, Hmieleski, & Pearce, 2006). Hmieleski and Ensley (in press) note that much of the failings of initial investigations on the individual differences of entrepreneurs resulted from attempts to identify overarching characteristics held by successful, but not by less successful, entrepreneurs without taking into account important contextual differences that moderate the relationships between the characteristics of entrepreneurs and the performance of the new

ventures that they lead. In this vein, by focusing on technological entrepreneurship we are likely to uncover important forms of knowledge and skills that may be less important, or even detrimental, when attempting to develop other types of more traditional new ventures, such as bookstores or restaurants. Not surprisingly, by focusing in on certain types of ventures, such as those with a technology orientation, studies have been able to identify particularly large effect sizes for the relationship of human capital variables with important entrepreneurial outcomes, such as firm growth (e.g., Ensley & Hmieleski, 2005). The articles in the current issue follow this trend by linking the human capital of technological entrepreneurs with several important entrepreneurial outcomes, such as: the amount of organizational learning captured from failed new product development initiatives, the degree to which products and services of technology-based new ventures are found to be innovative, the business-related social capital of technological entrepreneurs, the well-being of the end users of products developed by technological entrepreneurs, and the profitability and sales growth of technology-based new ventures.

In the next section we provide a more detailed overview of the articles comprising this special issue. Afterward, we consider what we foresee as some particularly fruitful areas for future research. Finally, we conclude with a summary of implications for policy makers and practitioners. Adding this public policy dimension is critical, since many nations and regions have adopted a variety of initiatives to stimulate technological entrepreneurship (e.g., the U.S. Small Business Innovation Research Program). Many of these programs are targeted at "agents" (e.g., scientists and entrepreneurs) and thus have important implications for the acquisition and development of human capital.

Contributions to the Special Issue

In this section we summarize the contributions of the articles in this special issue. The articles adopt a range of approaches including quantitative and qualitative studies. Both cross-sectional and longitudinal data collections have been employed. A variety of country contexts are covered, including developed economies (e.g., United States, United Kingdom) and an emerging economy (India). Technological entrepreneurship is also considered in a variety of institutional settings including universities spin-offs and patenting by academics, corporate entrepreneurship, new technology-based ventures, and social entrepreneurship. The presented articles adopt a range of theoretical perspectives including human capital theory, agency theory, cognition theory, and social capital theory (see Table 1 for a summary). In addition, the articles cover three principal levels of analysis: firm level, team level, and individual level, with some incorporating more than one level.

One of the true measures of success for technological entrepreneurs is the extent to which they are able to develop and bring to market radically innovative new products and/or services. Radical innovations are important not only for the positive economic impact they typically create, but also because they fundamentally change the behavior of consumers, often in ways that improve their lives. Marvel and Lumpkin take on this important topic by considering the degree to which the human capital of entrepreneurs relates to their ability to create radical innovations. Going beyond the general literature on human capital, these authors examine the effects of both the general (i.e., experience depth, experience breadth, and formal education) and specific (i.e., knowledge of ways to serve markets, knowledge of customer problems, knowledge of markets, and knowledge of technology) human capital of technological entrepreneurs on the degree to which their ventures deliver radically innovative products and services.

Table 1

Summary of Articles

Author	Research question	Theory(ies)	Sample and data	Analytical method	Main finding(s)
Marvel and Lumpkin	Which forms of general and specific human capital are most highly related to the degree of "innovativeness" in the products and services developed by technology-based new ventures?	Human capital	145 technological entrepreneurs leading new ventures based in incubators located in the Midwest of the United States were surveyed	Hierarchical regression analysis	In terms of general human capital, formal education was found to be most highly related to the degree of innovativeness. For specific human capital, technology-related knowledge was found to be most highly related to innovativeness.
Corbett, Neck, and DeTienne	Intersection between new product development (NPD) failures and entrepreneurial cognition; the processes associated with project termination and resulting actions that may lead to organizational learning; cognitive scripts used by corporate entrepreneurs to terminate failing NPD ventures	Cognition (termination scripts)	246 interviews over three-year period in 11 industry-leading radical innovation firms; archival data	NVivo text analysis software; theory building	Corporate entrepreneurs in technology-based firms use three types of termination scripts: undisciplined termination, strategic termination; and innovation drift; organizational learning can be maximized by use of termination scripts that allow for the capture of learning.
Majumdar	Is privatization associated with an increase in human capital and firm productivity?	Agency theory; human capital	Longitudinal data on human capital productivity and firm performance for *all* industrial firms in India (hundreds of thousands of Indian firms)	Regression analysis	There was a substantial degree of privatization in Indian industry, as a result of the growth of private entrepreneurship in India. This resulted in a significant increase in human capital productivity across all ownership categories of Indian industry. This wave of privatization may also be responsible for the rapid development of India's high-technology sector and the concomitant increase in technological entrepreneurship.
Packalen	How do an entrepreneurial team's prior work experiences, affiliations, and their status help provide legitimacy and access to resources for new ventures?	Organizational legitimacy; individual and organizational status; human capital; social capital	5 illustrative examples from biotechnology sector based on face-to-face interviews and archival data	Theory paper	An organization's initial legitimacy and ability to obtain resources is derived from interaction between three main facets of its founders' backgrounds: industry status, entrepreneurially relevant past experiences and other demographic features, and social capital. The presence of one type of capital may reduce the dependence on or need for others.

Shrader and Siegel	Are entrepreneurial team characteristics related to the competitive strategies and financial performance of technology-based new ventures?	Human capital	Longitudinal data on the strategies, entrepreneurial team characteristics, and financial performance of 198 high-tech ventures	Hierarchical regression analysis	The findings strongly suggest that the *fit* between strategy and team experience is a key determinant of the long-term performance of high-tech entrepreneurial ventures. For small, technology-based new ventures, the team's technological experience appears to be the most important determinant of the success of a differentiation strategy.
Mosey and Wright	How do differences in the human capital derived from the entrepreneurial experience of academic entrepreneurs influence their ability to develop social capital?	Human capital and social capital	Longitudinal study of 24 academic entrepreneurs (6 nascent, 12 novice, 6 habitual) and 20 technology transfer officers (TTOs) and heads of schools; archival data	Descriptive statistics; theory building	Habitual academic entrepreneurs more effectively build commercial ties regardless of discipline, while this is so for nascents and novices in engineering but not biotech. Prior business ownership experience is more valuable in gaining management knowledge and equity finance from external networks. Novices in engineering value TTOs more highly than do nascent and habitual entrepreneurs. Relationships with academic colleagues are important but for different resources according to experience. Management knowledge and finance gained by habitual entrepreneurs through repeated open-ended relations built on trust, by nascents and novices in engineering through joint ventures brokered by TTOs.
Allen, Link, and Rosenbaum	What type of faculty member is most likely to engage in entrepreneurial activity?	Human capital	National Science Foundation Survey of the patenting activity of 1,335 faculty at American universities	Regression analysis	Older faculty and those with tenure are more likely to engage in entrepreneurial activity. The authors interpret this result as signifying that tenure and age enhance the "absorptive capacity" of faculty members, with respect to the commercialization of innovation.
Terjesen	How can the human capital of entrepreneurs be leveraged to provide technological advances to assist those in need, and develop human capital within struggling societies, so as to empower underprivileged groups to create their own technological advances and become proactive in improving their overall well-being?	Human capital; micro-credit; sustainable development theory	Longitudinal telephone and face-to-face interviews 2004–2006 with key stakeholders; field visits; archival data	Case study analysis of rat catching activities in village in India	

Their results found both the general and specific human capital of the technological entrepreneurs studied to be significantly related to the degree to which the products and services delivered by their ventures were radically innovative. Further, both general and specific human capital variables independently accounted for a nearly equivalent amount of unique variance in innovativeness, suggesting that technological entrepreneurs hoping to develop breakthrough technologies should place a priority on developing both types of human capital over time. More specifically, the results of Marvel and Lumpkin's study suggest that acquiring additional formal education and acquiring knowledge of technology are likely to be particularly beneficial.

One of the most common problems that face technology-based entrepreneurs is how to decide when to terminate new product development (NPD) projects that are not meeting expectations. Corbett, Neck, and DeTienne consider the impact of human capital on this decision through an entrepreneurial cognition lens. Their 3-year longitudinal study of corporate entrepreneurs within 11 of the world's largest technology-based firms examines the types of cognitive scripts (i.e., metal frameworks of ordered steps to be taken within a certain context and relating to a specific set of activities) that are most commonly used to make termination decisions. In addition, their investigation evaluates the extent to which each of the identified scripts either enhances or inhibits organizational learning.

The "termination" scripts identified in their study include: undisciplined termination, strategic termination, and innovation drift. Undisciplined termination scripts comprised a quick decision to kill a project, without taking in to regard potential learning opportunities. In such cases, projects were prematurely ended, without fully considering the range of benefits that could emerge from continuation of the project or from taking the time to slowly downturn the project in such a way that would allow for an evaluation of what went wrong. Strategic termination scripts allowed for the organization to reflect about what went wrong before fully terminating the project. In such cases, organizations were able to learn through their failures and were less likely to make the same mistakes in the future. Innovation drift scripts allowed for failing projects to drag out for too long. This allowed for greater learning to occur than undisciplined termination, but not without a large cost. These firms would have learned more by ending projects earlier, capturing whatever knowledge they could from their failures, and moving on to other projects. These findings highlight how cognitive scripts can impact the amount of learning that takes place within the context of technological entrepreneurship—and in essence, the degree to which human capital is able to be developed and used to benefit future technology-based initiatives.

Majumdar conducts a comprehensive analysis of panel data for the entire population of industrial firms in India. He finds that there was a substantial degree of privatization in Indian industry, as a result of the growth of private technological entrepreneurship in India. This wave of privatization may also be responsible for the rapid development of India's high-technology sector and the concomitant increase in technological entrepreneurship. More importantly, the author reports compelling evidence that privatization resulted in a large increase in human capital productivity across all ownership categories of Indian industry, as well as substantial improvement in firm performance. These findings demonstrate the important role that technological entrepreneurship can play in the development of emerging economies.

The importance of social and human capital is further extended in the article by Packalen, which formulates a framework considering the interaction between three main facets of founding teams' backgrounds: industry status, entrepreneurially relevant experience and other human capital features, and social capital. Packalen develops a number of propositions that suggest that the presence of one type of capital may reduce the dependence on or need for others. First, as the status of founding teams increases, the

cognitive legitimacy of their firms and ability to obtain external resources will increase. Second, the greater the number of entrepreneurially relevant demographic features among founding team members, the greater will be their firm's cognitive legitimacy. In addition, industry status likely moderates the relationship between entrepreneurially relevant demographic features and the firm's cognitive legitimacy in an inverted-$\mathcal{U}$ shape such that the positive relationship between the two will be weaker at the lowest and highest levels of status. Third, as the number of organizations affiliated with members of founding teams increases, their firm's cognitive legitimacy will increase. Industry status will moderate this relationship between social capital and firm's cognitive legitimacy such that the strength of the positive relationship between the two will diminish as the level of status increases. The entrepreneurially relevant demographic features of founding teams will also moderate this relationship between social capital and firms' cognitive legitimacy such that the strength of the positive relationship between the two will diminish with a higher number of demographic features. Packalen argues that the model has particular applicability to a variety of industries with uncertain outcomes resulting from the commercialization of early stage technology (e.g., biotechnology, nanotechnology, software or hardware) or subjective quality (e.g., restaurants or movies). The application of the model is illustrated with examples from the biotechnology sector.

Shrader and Siegel conduct a longitudinal analysis of the role of human capital in the growth and development of 198 new technology-based ventures. Their results imply that the *fit* between strategy and team experience is a key determinant of the long-term performance of high-tech entrepreneurial ventures. For example, while a differentiation strategy was positively related to the profitability and sales growth of technology-based new ventures led by top management teams with high levels technological experiences, these important outcomes were negatively related to a differentiation strategy for start-ups led by teams with little technological experience. These findings demonstrate the importance for technology-based new ventures to select strategies for which they possess the human capital to successfully execute.

The debate concerning how technology-based entrepreneurs overcome the barriers to opportunity recognition and exploitation has focused primarily on skills shortages. Mosey and Wright seek to extend existing literature by developing theory relating to how differences in the human capital derived from the entrepreneurial experience of academic entrepreneurs influences their ability to develop social capital that can address the barriers to venture development. Using a longitudinal study of 24 academic entrepreneurs supplemented with interviews with 20 technology transfer officers (TTOs) and heads of schools, they examine the development of social capital by three types of academic entrepreneurs with differing levels of entrepreneurship experience: nascent, novice, and habitual entrepreneurs. They observe critical differences between the structure, content, and governance of social networks utilized to develop early stage ventures.

Mosey and Wright propose that habitual entrepreneurs (i.e., those with prior business ownership experience) have broader social networks and are more effective in developing network ties to gain equity finance and management knowledge. By contrast, less experienced entrepreneurs are likely to encounter structural holes between their scientific research networks and industry networks. This constrains their ability to recognize opportunities and gain credibility for their fledgling ventures. They also propose that while support initiatives, such as technology transfer offices and proof of concept funds, help attract industry partners to selected novice entrepreneurs, there appears to be no obvious substitute for business ownership experience to learn how to build relationships with experienced managers and potential equity investors. Interestingly, they also find that development of social capital for nascent and novice entrepreneurs is influenced by the

human capital related to the entrepreneurs' discipline-base, with individuals from engineering and material sciences being more likely to build network ties outside their scientific research networks than those in biological sciences and pharmacy.

Allen, Link, and Rosenbaum conduct an empirical test of human capital theory by analyzing data on the propensity of American academics to engage in entrepreneurial activity via patenting. The authors report that older faculty and those with tenure are more likely to engage in entrepreneurial activity. They interpret this result as signifying that tenure and age enhance the "absorptive capacity" of faculty members, with respect to the commercialization of innovation.

An area recently receiving increased attention is the intersection of technological entrepreneurship and social entrepreneurship. The primary concern here is how technological entrepreneurship can be used as a tool to enhance societal well-being. In this regard there appears to be great potential for considering not only how the human capital of entrepreneurs can be leveraged to provide technological advances to assist those in need, but also to develop human capital within struggling societies, so as to empower underprivileged groups to be able to create their own technological advances and become proactive in improving their overall well-being. Terjesen's case study of the Irula tribe of India speaks to both of these points.

There are approximately 3 million Irulas within southeast India. They are an impoverished people, living removed from society, without running water, electricity, and many other accoutrements that have become common to most modern civilizations. Their primary source of income and food is provided through rat catching. Until recently, the Irula depended on the use of a device, which was both inefficient and unhealthy to operate, to unearth rats from burrowed holes. Sethu Sethunarayanan, director of the nonprofit Center for the Development of Disadvantaged People, identified the rat catching device of the Irula as being a serious impediment to their well-being. The case reviews how he was able to exploit this opportunity in such a way as to maximize the benefits to the Irula people, following critical decisions that were made along the way.

Suggestions for Further Research

In the light of the articles presented in this special issue, we now offer some suggestions for further research. We segment our discussion by level of analysis, focusing on firms, teams, and individuals.

Firm Level

Increasing evidence suggests that technology-based ventures are not homogeneous. Some technology-based firms are spin-offs from existing corporations while others are spin-offs from universities. Within universities there may also be heterogeneity. Wright, Clarysse, Mustar, and Lockett (2007), for example, identify three types of spin-offs from universities: venture capital backed spin-offs, prospector spin-offs, and lifestyle spin-offs. Each type may require different forms of human capital. For example, venture-backed spin-offs are likely to require entrepreneurial teams consisting of both technological and commercially oriented management, perhaps partly recruited from outside the university, while lifestyle ventures may comprise researchers and professors with consulting experience. These human capital attributes may also need to be complemented by incubator environments that provide appropriate financial and network resources (Clarysse, Wright,

Lockett, van de Velde, & Vohora, 2005). Major challenges arise when there is a mismatch between the ability of the incubator environment to provide the resources that the venture requires. Additional research is required to understand the nature of complementarities and substitutabilities of the human capital and other resources involved in the development of different types of technology-based spin-offs. Further complicating matters is the fact that different forms of human capital may be required to lead each of these types of ventures within different stages of development. For example, different forms of human capital may be needed for identifying opportunities (e.g., creativity) during the initial stages of venture creation from that which is needed to lead the venture toward high growth (e.g., management skills).

Extensive research attention has been devoted to the growth of entrepreneurial ventures. Empirical studies exploring the outcomes of entrepreneurship have focused on various financial and nonfinancial yardsticks to measure firm-level growth and performance (Chandler & Hanks, 1993; Ensley et al., 2006). For technology-based ventures, employment may grow before any sales occur as the firm builds its product base (Brush, Greene, & Hart, 2001; Delmar, Davidsson, & Gartner, 2003); this growth in employment indicates an increase in the resources and value of the firm. It may also reflect the strategic choice adopted by technology-based ventures. They can adopt a product market strategy aimed at achieving growth in terms of revenues or a strategy where the objective is growth in the value of the technology with a view to an eventual exit through an Initial Public Offering (IPO) or a sale to a strategic partner (Gans & Stern, 2003). This choice is likely influenced by the nature of the appropriability regime and the accessibility of the complementary assets necessary to pursue each growth path. The choice of different growth trajectories has important implications for the nature of human capital required. Product market oriented growth strategies imply a need to acquire human capital with commercialization expertise. Markets for technology growth strategies suggest a need to acquire complementary human capital assets that can help develop the technology, for example, with respect to diversifying the technological platform, integrating with downstream technologies, and so forth. We know little about how firms access such human capital. For example, to what extent is this human capital accessed through direct recruitment, through joint ventures or through being acquired by incumbent firms?

There is also a need for further exploration of the potential link between human capital, technological entrepreneurship, and corporate governance. Articles in this special issue have considered technological entrepreneurship in different ownership contexts: public and private university spin-offs, spin-offs from private corporations and privatized enterprises. More specific and comparative analysis is required of the constraints imposed by different ownership forms on the development of technological entrepreneurship and of the associated different types of human capital that may emerge. To what extent does a change in ownership, for example from the public to the private sector help reduce these constraints? To what extent does board membership differ between these ownership contexts in order to fill different knowledge gaps of entrepreneurs?

Team Level

The composition and internal dynamics of entrepreneurial teams may be especially important for the development of technology-based ventures (Ensley & Hmieleski, 2005). Vohora, Wright, and Lockett (2004) identified four critical junctures in the development of technology-based academic spin-offs: opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability. Vanaelst et al. (2006) show how members of the entrepreneurial team change as the spin-off evolves in terms of both

exit and entry. For example, some researchers who are actively involved in the early stages, may leave the process before the formal creation of the spin-off. These researchers may decide to remain with the university as they prefer to pursue an academic career. With respect to team entry, a central issue is that while new team members may be brought in for their commercial skills, they may not have a different view on doing business from the initial academic founders. This leads to homogeneity at the expense of the heterogeneity that may be necessary to enable the firm to grow. Cognitive heterogeneity may be crucial for team members to challenge each other and arrive at better decisions about the spin-off's strategy (Wright et al., 2007). A central issue concerns the influence of the configuration of instrumental and noninstrumental relations between team members.

One potentially important source of the commercially oriented human capital required to develop spin-offs from universities are surrogate entrepreneurs (Franklin, Wright, & Lockett, 2001). While surrogate entrepreneurs have been identified as having a potentially important role to play, the processes for identifying and utilizing them in spin-off companies is not well understood. Their identification raises questions about the effectiveness of the social capital of TTOs. Their utilization as nonacademic people in the academic context creates challenging human resource management issues concerning their remuneration and potential conflicts of interest. Further studies are needed to analyze the appropriate timing for the introduction of surrogate entrepreneurs, the nature of the networks required to identify them, and whether they replace or complement the academic entrepreneur.

Individual Level

Mosey and Wright (2007) demonstrate important aspects of the heterogeneity of the human capital of academic entrepreneurs relating to business ownership experience and discipline base. A further dimension of human capital heterogeneity concerns differences between star and middle-range researchers. Lowe and Gonzalez-Brambila (2007), using U.S. evidence, show that academic entrepreneurs are among the most productive and highly cited in their respective fields.

Yet, middle-range researchers may also identify technology-based entrepreneurial opportunities. As yet, there is little systematic evidence regarding the differences in the technological base of businesses started by star and middle-range researchers, nor is there evidence on the relative success of such ventures. Do technology-based ventures created by star researchers involve more innovative products than those created by middle-range researchers? Are technology-based ventures created by middle-range researchers more likely to be aimed at meeting current market needs rather than creating entirely new markets?

Mosey and Wright, as well as Packalen, also show a link between human capital and social capital. A central issue for academic entrepreneurship activities is to integrate scientific knowledge with the commercial knowledge to enable a spin-off to develop. Typically, a gap exists between the holders of these two types of knowledge (Lockett et al., 2005). Commercial knowledge may be available either from outside a university or internally in technology transfer offices or business schools. Accessing this knowledge may be problematical. Nicolaou and Birley (2003) found that differences in the ways that academics were embedded in external or internal ties to the university may be associated with different growth trajectories. A central question concerns how these links are created. Within universities, academic entrepreneurship occurs at the boundaries of different scientific and professional backgrounds, creating a need for mechanisms to transcend these boundaries. Working across these boundaries may be particularly

complex as science departments, TTOs and business schools lack shared knowledge, goals, and assumptions (Davidsson, 2002). Similarly, with respect to external links, academics may have strong links with scientific networks but not with commercial networks. There is, therefore, a need for human capital that can span these boundaries. Boundary spanners are agents who gain knowledge from one domain and move it to be applied in another (Tushman & Scanlan, 1981). The distance between groups in terms of language, physical distance, and culture increases the importance of boundary spanning individuals (Kostova & Roth, 2003). Programs have begun to be introduced to provide boundary spanning activities. For example, in the United Kingdom, the government-funded Medici program was introduced to facilitate the commercialization of Biomedical research. Fellows of the program were provided with training led by practitioners from the Biomedical business community, TTOs, legal and regulatory professionals, finance providers, and business school faculty. Preliminary analysis of the impact of the program showed that it provided key skills but that attracting finance from business angels and commercial management to spin-offs proved challenging (Mosey, Lockett, & Westhead, 2006). Further research could usefully examine the nature of the human capital among boundary spanners and the appropriate sources of boundary spanners in both the university and corporate sectors.

The institutional context may pose challenges for human capital and technological entrepreneurship. In particular, emerging or transition economies may experience well-known shortages of resources, notably entrepreneurs. Yet, the development of entrepreneurship can transform industries, as the article by Majumdar illustrates. Where indigenous entrepreneurs are not available, there may be an important role for returnee entrepreneurs, that is, scientists and engineers trained in the United States or in other OECD countries, returning to their home countries to start new ventures. These returnee entrepreneurs, with human and social capital accumulated in a market economy, may help to stimulate the development of technology-based firms in emerging and transition economies. At present, analysis of the contribution of returnee entrepreneurs to technological entrepreneurship is limited. One exception is a study by Wright, Liu, Buck, and Filatotchev (2008), which presents evidence suggesting that science park location choices is related to the performance of ventures owned by returnee entrepreneurs in China. Further research might analyze the role of returnee entrepreneurs in differing contexts. For example, their role may be different in countries emerging from Communism compared to those that are emerging from an undeveloped position, such as India. Research might also consider the interactions between the human capital of returnee entrepreneurs and the availability of financial, social, and organizational support structures that are likely to be critical to technological entrepreneurship.

Finally, Table 1 shows that most studies presented in this special issue focus solely on human capital theory. While the emphasis on human capital theory is to be expected given our focus, further insights may be obtained by synthesizing different theoretical perspectives. For example, Mosey and Wright integrate human and social capital perspectives. To what extent does a synthesis of human capital with other perspectives, such as institutional theory, help in understanding the development of technological entrepreneurship in developed and emerging market contexts?

Conclusions

We conclude by offering some implications for policy makers and practitioners that have emerged from the studies comprising the current special issue as well as from

other recent investigations focusing on human capital and technological entrepreneurship. First, it appears that there may be great benefits in university programs that combine science and technology with business management. An example would be a dual MBA and MS in Engineering program including a major in entrepreneurship that focuses on the process of opportunity recognition and exploitation. Such programs can provide both critical knowledge to nascent entrepreneurs as well as a platform for connecting technologists with experienced managers. These links are especially important since business proposals developed by scientists are often "technology push"-oriented with little attention to the market opportunity. More simplified undertakings might include such activities as matching management with engineering students to work jointly on developing a feasibility analysis or business plan for commercializing new technologies. Some business schools have developed links with TTOs which enable MBA students, who have business experience, to become involved in a spin-off either in terms of developing business plans or in becoming part of the spin-off team. Undergraduate programs that provide entrepreneurship courses for scientists and engineers are also developing. However, teaching students entrepreneurship may not be the same as enabling them to become entrepreneurs and further support mechanisms may need to be developed to enable this to occur. To fully capitalize on these possibilities, policy attention may also need to be devoted to the development of sufficient human capital among business school faculty in order to enable them to effectively teach and support aspiring technological entrepreneurs. The distribution of entrepreneurship faculty in business remains uneven and few still have what might be considered a requisite critical mass of faculty (Finkle & Deeds, 2001). In the United Kingdom, for example, 31% of university business schools have only one entrepreneurship faculty member and 55% have between one and four entrepreneurship faculty (Wright, Mosey, Piva, Lockett, & Alferoff, 2006). A major challenge is the resolution of the dilemma that faculty required to contribute to the development of spin-offs may need to have considerably more practical experience than typical business school academics and as a result may be less able to contribute to academic research. Policy therefore needs to address the career structure and integration of faculty in business schools whose role is to promote academic entrepreneurship.

We suggest that even more fundamentally, primary school programs could be created that demonstrate to children and young adults the opportunity for careers that combine science and technology with business management. Promoting such possibilities to youngsters would help to position individuals, early on in life, to accumulate human capital across both of these general domains, and potentially lead to a greater incidence of new technology-based venture creation. Further, by providing boundary spanning role models of female technological entrepreneurs, who—as shown in this issue by Allen, Link, and Rosenbaum—are vastly underrepresented, during primary school education may be particularly effective toward increasing the proportion of women who become technological entrepreneurs. Efforts to promote technological entrepreneurship to youngsters should clearly articulate the societal benefits that can be created through technological entrepreneurship in order to facilitate an intrinsic attraction toward technology-based new venture creation.

In search of success stories, technology incubators (both university affiliated and independent) often push their resident ventures to grow as quickly as possible. This strategy can backfire if, as shown in this issue by Shrader and Siegel, the technology-based start-up does not possess both the technology and business know-how required to successfully manage high growth. In order to help technology-based ventures to survive, it would be advantageous to first assess whether they possess these essential forms of human

capital and, if they do not, develop a plan for moderate controlled growth, allowing the venture the opportunity to learn and acquire capabilities in these areas, as opposed to accelerating them toward a quick death.

An additional major policy issue concerns how to motivate university science and engineering faculty to get involved in technology transfer activities. Academics encounter an opportunity cost of undertaking commercialization activities, which is their investment in the skills of research, teaching and administration and the impact on career progression (Wright et al., 2007). There is a need to adapt tenure and reward systems so that commercialization is valued. For example, academic entrepreneurs may require time and space to devote to the commercialization of an idea, which may conflict with the demands of tenure clocks. There may also be a need for flexibility in financial reward structures for commercialization to encourage and retain star scientists. Aside from academics, there is also a need to develop remuneration and incentive mechanisms to attract and retain TTOs and surrogate entrepreneurs with the necessary human capital skills to create and develop spin-offs; these incentives may require a departure from regular university administrators' remuneration. More generally, these points imply an overarching need for the integration of commercialization into the portfolio of university activities rather than being an *ad hoc* addition as is often the case.

Finally, the article by Majumdar relating to the development of the private sector in India also highlights a further potentially important issue in the development of technology policy and technological entrepreneurship (Larédo & Mustar, 2001; Mustar & Larédo, 2002). Specifically, in some institutional contexts such as emerging and other economies where there has been heavy reliance on state ownership of industry, for technology policy to be successful in its widest sense (including software and IT as well as biotechnology, electronics, etc.), it may also be necessary to develop policy concerning the ownership and competitive structure of industry. In part this may involve the privatization of state enterprises. However, promoting the creation and development of private sector firms through enabling entry to sectors where they were previously prohibited (Geroski, 1995) and stimulating venture capital sectors (Wright, Clarysse, Lockett, & Binks, 2006), *inter alia*, may also have important roles to play.

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