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When Do Scientists Commercialize Their Inventions? Insights From the Theory of Planned Behavior

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Abstract

Commercializing university-based technology, which is sometimes called "academic entrepreneurship," can be difficult for scientists. Having been trained and socialized as scholars, many university-based researchers feel unprepared for or detached from the world of business. Recent research has identified some cognitive and behavioral factors that affect scientists' propensities to engage in academic entrepreneurship. However, such findings remain somewhat fragmented and in need of an organizing framework. In this article, we place some recent empirical findings on academic entrepreneurship behavior within the framework of the "Theory of Planned Behavior" (TPB), a widely researched, evidence-based theory from the field of social psychology. We also propose ways in which technology transfer administrators and others can draw useful insights from recent studies and from the TPB.

Introduction

What would you like to see in the future? Some common answers to this question might include a cure for cancer or other chronic diseases, or technologies that can help feed the world in ways that are environmentally sustainable. Companies are busy at work looking for solutions to important problems like these. But at least some of the knowledge we need to solve such problems can only be found in university-based research. At universities, scientific researchers spend decades studying specialized questions in fields such as chemistry, biology and engineering. These researchers push the limits of human knowledge and forge new paths for the businesses that ultimately commercialize new inventions. But in order for university-based knowledge to make it out of the laboratory, individual scientist-inventors need to take part in the commercialization process.

Commercializing university-based technology, which is sometimes called "academic entrepreneurship," can be hard for scientists. Having been trained and socialized as scholars, these researchers often feel unprepared for, overwhelmed by, or detached from the world of business (George & Bock, 2009; Jain et al., 2009). Recent research has uncovered some micro-level factors that affect scientists' propensities to engage in academic entrepreneurship. However, past micro-level findings in this area remain somewhat fragmented. An organizing framework, we suspect, could help advance research in this area and, at the same time, help practitioners seeking to draw insight and guidance from that research. In this article, we attempt to advance research and research-informed practice in this area by placing some of the most recent empirical findings on academic entrepreneurship behavior within the framework of the "Theory of Planned Behavior" (TPB), a widely researched, evidence-based theory from the field of social psychology (Ajzen, 1991).

The TPB seeks to predict individual-level behavior. Accordingly, we review recent empirical publications that show how micro-level variables affect a person's decision to engage in academic entrepreneurship, and we explain how these various pieces can be integrated into a TPB-based model of academic entrepreneurship behavior. In doing so, our intentions are to help organize and integrate existing work in this area as well as to aid in the interpretation of that work by drawing some practical insights from recent studies and from the TPB. Ultimately, too, we hope to stimulate future research on academic entrepreneurship from a TPB perspective.

Background

In recent decades, social scientists have begun to study academic entrepreneurship (e.g., Rothaermel et al., 2007; Siegel & Wright, 2015), and their research has helped us understand what universities, departments

and others can do to better cultivate academic entrepreneurship on campus. Much of the research on academic entrepreneurship has focused on relatively macro-level factors that shape the practice of academic entrepreneurship, such as the structures, policies or cultures that operate within certain universities or countries (Perkmann et al., 2013; Siegel & Wright, 2015). Therefore, not surprisingly, the focus of most reviews of the academic entrepreneurship literature has been on these structures and policies (e.g., Balvern et al., 2018; Rothaermel et al., 2007). Proceeding from this observation, Balvern and colleagues (2018) concluded their recent literature review by arguing that improving our understanding of academic entrepreneurship will require a deeper consideration of micro-level factors, including the beliefs and behaviors of individual scientists.

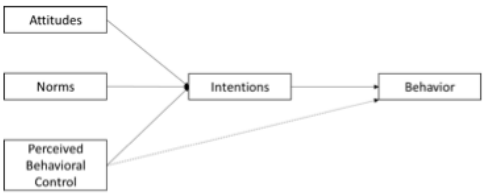
Some research on micro-level phenomena in academic entrepreneurship has begun to accumulate, as is evident from several reviews recently published in a special issue of the Academy of Management Perspectives (Hmieleski & Powell, 2018; Nikoforou et al., 2018). One of these reviews highlighted ways in which individuals' engagement in academic entrepreneurship is influenced by their backgrounds and characteristics – including their prior entrepreneurial experience and publication history – as well as characteristics of their immediate social environments, such as the structure of their professional networks or the behavior of their colleagues (Hmieleski & Powell, 2018). Another of these reviews discussed the entrepreneurial teams formed by academic entrepreneurs, detailing for example the human and social capital assembled within such teams (Nikiforou et al., 2018).

These recent reviews have identified some important micro-level factors that influence academic entrepreneurship, and they have helped to map the scope and breadth of the variables considered in past work. At the same time, however, past micro-level findings remain somewhat fragmented; there has yet to emerge in this area of research a clear organizing framework that elaborates how micro-level variables interact to affect entrepreneurial outcomes. We propose a way to fill this gap by placing some of the most recent empirical findings on academic entrepreneurship behavior within the framework of the TPB. To this end, we have assembled a set of publications that includes some pieces that were included in recent reviews as well as other articles not included in any recent reviews, and we explain how these various pieces can be integrated into a TPB-based model of academic entrepreneurship behavior.

APPLYING TPB TO ACADEMIC ENTREPRENEURSHIP

The TPB proposes that a person's propensity to engage in various behaviors can be predicted based on a set of cognitive factors that underlie the formulation of intentions. Specifically, the TPB posits that a person's intention to engage in a given behavior is a function of three key factors: 1) the person's attitude towards the behavior (i.e., believing that the behavior in question is desirable), 2) the person's perception of relevant social norms (i.e., believing that others think the behavior is valuable or appropriate), and 3) the person's perceived behavioral control (i.e., believing one has the ability to perform the behavior). In general, the TPB holds that these factors operate through the formation of intentions, although the theory also accounts for the possibility that perceived behavioral control can influence behavior independent of intention. Social psychologist Icek Ajzen formulated the TPB in a series of articles around thirty years ago (Ajzen, 1985, 1987, 1991), and the theory has been elaborated and refined in subsequent work (Conner & Armitage, 1998; Montano & Kasprzyk, 2015; Pavlou & Fygenson, 2006). The TPB is depicted in Figure 1.

Figure 1. The Theory of Planned Behavior



Empirically, the TPB has been applied in a variety of research domains and has been found to be a robust predictor of various planned behaviors, including health behaviors (e.g., Armitage & Christian, 2003; Hardeman et al., 2002), technology adoption behaviors (e.g., Pavlou & Fygenson, 2006), and environmental behaviors (e.g., Greaves, Zibarras, & Stride, 2013). For

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example, in the area of health psychology, a meta-analysis of 204 experimental studies indicated that changes in attitudes, social norms and perceived behavioral control all produced changes in health-related intentions and health-related behaviors, such as increasing physical activity, stopping smoking, or reducing alcohol consumption (Sheeran et al., 2016). The analysis further found that these changes were generally not qualified by moderator variables, such as features of the target behavior.

We are not the first researchers to apply the TPB to entrepreneurial behavior. Past scholars have used the TPB framework to examine how specific individual factors shape entrepreneurial intentions and behavior (e.g., Kautonen, van Gelgeren, & Fink, 2015; for a review see Lortie & Castogiovanni, 2015). Some studies have even applied TPB to the behavior of academic entrepreneurs, in particular (e.g., Goethner, Obschonka, Silbereisen, & Canter, 2012; Obschonka, Goethner, Silbereisen, & Canter, 2012). For example, Goethner and colleagues (2012) found that academic scientists with more positive attitudes toward entrepreneurship and higher levels of perceived behavioral control had stronger entrepreneurial intentions. Notwithstanding these contributions, further applications of the theory are warranted. For example, Lortie and Castogiovanni (2015) conducted a comprehensive review of the TPB in the entrepreneurship literature and observed that many researchers have examined only small pieces of the theory or generated simple face-valid measures of the theory's components without careful considering the full theory and its origins.

In this review, we focus on recently-published empirical studies that examine the entrepreneurship-related cognitions and behaviors of university-based scientists. Rather than setting out to review articles that explicitly invoke TPB, however, we have taken a broader, more inclusive approach that accounts for the possibility that past studies of various cognitive constructs may be relevant to developing a TPB-based understanding of academic entrepreneurship even when those studies do not explicitly invoke TPB. For example, we categorize "entrepreneurial passion" as an attitude, because it has been defined as "a consciously accessible, intense positive feeling" (Cardon et al., 2009), and this in turn suggests a favorable perception of entrepreneurial behavior. This inclusive approach enables us to assemble a wider range of empirical studies that can be used to inform practitioners and helps us to better illustrate the long-term potential for TPB to illuminate behavior in this context.

Scope of this Review

In conducting this review, we searched for articles published in the last 12 years that focused on individual or other micro-level characteristics of university-based scientists being studied as actual or potential academic entrepreneurs. We began with a database search for articles published in leading management and entrepreneurship journals, including Academy of Management Journal, Administrative Science Quarterly, Entrepreneurship Theory & Practice, the Journal of Business Venturing, Management Science, Organization Science, Research Policy, Strategic Entrepreneurship Journal, and Strategic Management Journal. This search yielded 25 articles. We also looked at articles identified in several recent reviews published in Academy of Management Perspectives as well as several additional articles that we knew to be topical from other management journals, including the British Journal of Management, Journal of Product Development and Management, Journal of Small Business Management, Journal of Economic Psychology, R&D Management, and Technovation. We then conducted a more thorough examination of the studies we found focusing on variables that could be categorized as at least one of the three core TPB constructs (i.e., attitudes, social norms, or perceived behavioral control).We focused in particular on those variables that had an effect on whether an individual engages in or succeeds at academic entrepreneurship. On this basis, we narrowed the pool of articles to 16 articles which focused on these characteristics ***(Download Table 1: TPB-Related Research)***.

Studies of Attitudes

Several studies examined variables that captured some aspect of scholars' attitudes towards academic entrepreneurship. These studies found evidence that an individual's positive or negative evaluation of entrepreneurial activity is related to entrepreneurial intentions and behaviors. For example, using surveys from 213 doctoral students, Feola and colleagues (2017) found that a more positive attitude toward starting a firm based on the results of one's research was related to stronger intentions to engage in academic entrepreneurship. Attitudes were also explored in a study by Goethner and colleagues (2012), which featured a survey of 496 German research

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scientists, approximately 75% of which were in a university setting. This study revealed a positive relationship between attitudes toward academic entrepreneurship and entrepreneurial intentions after controlling for gender, age, PhD degree, and type of research.

Using in-depth interviews with 44 academic scientists, Gumusay and Bohne (2018) found that one of the major barriers to engagement in academic entrepreneurship was that many scientists had a negative view of the process. For example, some academics viewed entrepreneurship behavior as "selling one's soul", impure, or simply as outside the scope of their work (Gumsay & Bohne, 2018). Furthermore, they viewed academic entrepreneurship as an activity that could hinder, rather than advance, their career progress (Gumsay & Bohne, 2018). Not surprisingly, these attitudes were associated with decreased interest in engaging in entrepreneurial behaviors.

Other negative attitudes towards entrepreneurship have been identified among scientists. Karatas-Ozkan & Chell (2015) conducted focus groups and interviews with a sample of 52 academics, postdoctoral researchers and graduate students. Inductive analyses of these transcripts suggest that the women in their sample tended to view academic entrepreneurship – and commerce generally, in fact – as a gendered process within which masculinity and masculine traits are favored. For this reason, many women scientists in the sample described a negative attitude toward academic entrepreneurship and tended to report that they were less likely overall to intend to engage in it.

Marion, Dunlap, & Friar (2012) found that some of the most successful academic entrepreneurs not only did not have negative attitudes toward entrepreneurial behavior, but in fact viewed starting a company as an integral stage of the maturation of their line of research. These researchers regarded commercialization as a successful culmination of carefully planned research rather than as a process of selling out. Jain, George, & Maltarich (2009) further found that academics involved in commercialization are more likely to view entrepreneurial behavior as an activity that enhances the societal impact of their academic work, rather than as a hindrance to it. Their essential finding suggests that academics fall on a continuum from "pure scientist", for whom publication and public dissemination are most important, to "pure entrepreneur", for whom commercialization is most important, with "hybrid" scientists falling in the middle.

Lam (2011) laid out a framework in which she proposed a scientist's "orientation", a construct that closely resembles the TPB attitude construct. Specifically, Lam identified four types of university scientists with differing attitudes toward university-industry links and different intentions to engage in entrepreneurial behavior. The pure traditionalist has a negative view of industry, believing that academics should not engage in entrepreneurial or industry-related behavior and instead that their efforts should remain purely academic. The pragmatic traditionalist has weaker negative attitudes toward industry: although they believe scholars' focus should be on academic endeavors, they understand the occasional need for industry collaboration. A hybrid type has a generally positive view of industry-scientist collaborations, including the belief that these collaborations can lead to scientific advancement, but hybrid scholars are simultaneously careful to maintain their commitment to their core academic and scientific values. An entrepreneurial type has a positive view of scientific-business collaboration, believes it is important for scientific progress, and sees little need for boundaries. Perhaps unsurprisingly, these types exhibited different associations with entrepreneurial behavior. For example, 93% of entrepreneurial types had industry links whereas this was true of only 60% of pure traditionalists.

A recent study which included interviews from over 2,000 researchers from 24 European universities found that individuals' entrepreneurial and scientific passions played a role in whether a person chose to engage in academic entrepreneurship (Huyghe, Knockaert, & Obschonka, 2016). Specifically, they found a significant interaction between entrepreneurial passion and "obsessive scientific passion", or a passion for scientific work that occupies an especially central and disproportionate role in a person's identity. Cases in which scientists had both obsessive scientific passion and entrepreneurial passion were those in which scientists exhibited the strongest intentions to start a company based on their own scientific findings. Although entrepreneurial passion in the absence of scientific passion was positively related to entrepreneurial intentions, these individuals were less concerned with whether their start-up was directly related to their research.

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In summary, these findings indicate that scientists' attitudes towards entrepreneurship vary considerably, and they suggest that these attitudes are likely to affect scientists' participation in academic entrepreneurship regardless of incentives or institutional pressures.

Studies of Social Norms

In the TPB, the social norms construct includes both "injunctive" and "descriptive" norms (Cialdini, Kallgren, & Reno, 1991; Cialdini, Reno, & Kallgren, 1990). Injunctive norms are a person's perception of what behaviors others approve or disapprove of, or what one ought to do according to society, whereas descriptive norms correspond to a person's perception of what others are actually doing. As it applies to the academic entrepreneurship context, an example of an injunctive norm would be a scholar's perception of whether relevant others approve of scholars engaging in entrepreneurial behavior, whereas an example of a descriptive norm would be the scholar's perception of whether other scholars are indeed engaging in entrepreneurial behaviors.

Injunctive norms have been shown to be important predictors of people's behaviors. Using a sample of 89 academic inventors from 45 different spinouts, Nicolaou and Souitaris (2015) found that those inventors with higher perceptions of institutional support were less likely to create a spinout outside of the university. (Here "institutional support" had to do with the inventors' perceptions regarding the availability of advice, procedural guidance, and management training within their university.) This relationship between perceived support and spinout creation was further enhanced by inventors' perceptions of positive social norms within their departments. Similarly, Feola and colleagues (2017) found that Ph.D. students who reported that their colleagues, friends, and familiars would be supportive of them starting their own business had stronger intentions to engage in academic entrepreneurship. Using a sample of 79 interviews of academic entrepreneurs, Hayter (2016) found that the social networks of early-stage academic entrepreneurs were primarily comprised of other academics, including both other academic researchers and graduate students. This would seem to suggest that other academics' opinions of entrepreneurial behavior are important for supporting and motivating academic entrepreneurs at this early stage. Specifically, several of the academic entrepreneurs interviewed specifically noted that they likely would not have even started their ventures if their academic contacts had not encouraged and supported them to do so. In other words, the scientists may not have considered entrepreneurship to be an option if those close to them had not thought it was something they ought to do.

In a separate longitudinal study of eight university spin-offs, championing and support from more senior professors and one's department were shown to be important predictors of the developmental path of the spin-off (Rasmussen, Mosey & Wright, 2014). Specifically, founders in departments where management and senior professors supported and championed the spin-off – i.e., where it seemed that spin-offs were something that one ought to take part in – were more likely to develop important entrepreneurial competencies, an important step in advancing their long-term success. Moreover, a lack of support from these actors was associated with scholars maintaining more secrecy about their ventures and with a slower, more siloed, and more constrained evolution of their spin-offs.

Other studies have revealed the importance of local descriptive norms on academics' propensity for entrepreneurial behavior. Using data from a large sample of faculty from 15 universities, Bercovitz & Feldman (2008) found that the norms within scientists' current departments were more predictive of those scientists' technology transfer behavior than whether they had received their graduate training in a program with strong technology transfer norms. Specifically, academics who had been trained with strong technology transfer norms but who currently resided in departments with more traditional norms (i.e., those which regard technology transfer less favorably) tended to behave like scientists in their current departments. The reverse was true for those who had been trained with traditional norms but were currently in departments with stronger technology transfer norms.

Other findings point to the importance of even more localized norms: those of scholars' co-authors. Aschoff & Grimpe (2014) examined the publication history and social networks of 355 German academics and found that their involvement with industry, as measured by industry collaborations, was affected by the industry involvement of both their departments and their co-authors. Specifically, they found that scientists with co-authors who had higher rates of involvement with industry were more likely to be involved with industry themselves. In additional, individuals in departments

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with higher rates of industry involvement were more likely to be involved with industry themselves, an effect that was especially strong for younger scientists. Finally, they found that when one's co-authors and department differ in their extent of industry involvement, younger scientists tend to be more congruent with their department whereas older scientists' involvement levels tend to be more congruent with those of their co-authors.

Studies of Perceived Behavioral Control

Perceived behavioral control is the extent to which a person believes he or she can engage in a given behavior, based on perceived facilitators and barriers. The focus of this construct is on the extent to which individuals perceives themselves as being able to engage in a a certain behavior given a set of circumstances. For example, your perceived behavioral control of your diet might decrease if you knew you were going to be attending a party that evening, but the same objective barrier—the party—may not decrease your friend's perceived behavioral control.

One of the primary means by which people are likely to judge their ability to overcome barriers is by their perceptions of their own ability. Results from a study of 6,200 academic researchers who received grants from the UK Engineering and Physical Sciences Research Council between 1992 and 2006 revealed that people's perceptions of their own entrepreneurial capacity were one of the strongest predictors of the likelihood that they would become involved in a venture as a founder or co-founder during the study period (Clarysse, Tartari, & Salter, 2011). Specifically, the degree to which people agreed with such statements as, "I frequently identify opportunities to start-up new businesses (even though I may not pursue them)," was found to be a more robust predictor of new venture involvement than contextual variables, such as department quality or the presence of a technology transfer office.

Similarly, Feola and colleagues (2017) found that Ph.D. students who were more confident that they could start a firm based on the results of their research reported stronger intentions to engage in academic entrepreneurship. Goethner and colleagues (2012) similarly found a positive link between perceived behavioral control for entrepreneurship and entrepreneurial intentions. Finally, using samples from two different European universities, researchers found that entrepreneurial self-efficacy, a measure of the degree to which the scientists believed they could perform entrepreneurial tasks (e.g. develop new products, develop new services) was the strongest predictor of entrepreneurial intentions in their model, a model which included variables such as number of patents, type of research, and number of years spent at the academic institution (Prodan & Drnovsek, 2012).

One of the major issues nascent entrepreneurs face related to perceived behavioral control is their own perception of barriers (Gumsay & Bohne, 2018). Gumsay & Bohne (2018) conducted interviews with 55 academic entrepreneurs and their support staff and found that one of the main barriers people identified in connection with academic entrepreneurship had to do with their perception that they lacked the "right" contacts. Their interviewees emphasized that they felt that they did not have experienced entrepreneurs or business people in their social networks and that they did not know how to gain these contacts. These perceptions are additionally related to nascent entrepreneurs' general perception that they lack the skills and expertise to be a successful entrepreneur. In addition, many informants stressed that they do not feel like they have access to professional development in these areas (e.g. negotiation, marketing), leaving them feeling as though they are at a loss in terms of moving forward with an entrepreneurial project, even if they have the time and interest to do so.

Although Fini, Lacetera, & Shane (2010) do not directly engage with the concept of perceived behavioral control, their findings speak to the importance of perceived opportunities and barriers to engagement in academic entrepreneurship. Specifically, they found that a majority of academics in their sample engaged in entrepreneurial activity that was outside of the formal university structures. They also found that the types of academics who do not follow formal structures differed from those who do, suggesting that some individuals, perhaps, do not engage in entrepreneurial behavior because they perceive these formal structures to be too limiting in some way.

Past experience, both positive and negative, also has a profound effect on entrepreneurs' likelihood of engagement in start-ups and spinoffs, and the effects of experience appear to operate through people's perceptions of barriers. One of the greatest reported

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concerns of experienced entrepreneurs was protecting nascent entrepreneurs from negative social contacts who might "burn" them (Gumusay & Bohne, 2018). Despite this, past entrepreneurial experience has been shown to be related to increased spin-off and start up intentions (Huyghe et al., 2016) and to an increased likelihood that one's invention will lead to the formation of a startup (Marion, Dunlap, & Friar, 2012).

IMPLICATIONS

The studies reviewed above have practical implications for people interested in fostering or supporting academic entrepreneurship among university-based scientists. This includes technology transfer officers, academic administrators, and department chairs as well as people beyond universities, such as policymakers, private investors, or industry executives involved in university-based startup or licensing activities. People in all of these roles – whom we'll call "practitioners" collectively – may be able to perform their roles more effectively by drawing insight from the theory of planned behavior in this context and, accordingly, paying more direct attention to scientists' own attitudes toward and perceptions of academic entrepreneurship.

Raising Awareness

First, practitioners should watch closely for inconsistencies between policies and practices at the university level and the beliefs and norms maintained by scientists at lower levels, such as departments and research groups. This is because most scientists' attitudes and beliefs are more strongly shaped by their day-to-day interactions with colleagues than by their universities' formal policies and structures.

At the most basic level, practitioners may need to cultivate greater awareness of entrepreneurial opportunities among scientists. Recent work by Huyghe and colleagues (2016) showed that fewer than half (44%) of the researchers at 24 European universities were even aware of the existence of a TTO at their university. Awareness was especially low, they further found, among researchers who did not have prior entrepreneurial or consulting experience. To the extent that awareness is a prerequisite to more elaborate perceptions of academic entrepreneurship, these data suggest that practitioners need to be prepared to engage scientists – and to help scientists engage with each other – at very different levels of understanding. For example, although TTO communications focused on the finer points of patenting or equity ownership may be salient to some scientists, other scientists will likely need help developing a more foundational understanding of academic entrepreneurship.

Communicating with Scientists

Of course, what and how faculty communicate with each other is also critical. For example, even if academic entrepreneurship is praised by university administrators and induced through carefully-crafted incentive schemes at the institutional level, such promotional efforts can be significantly undercut by the informal conversations scientists have with their peers in hallways and laboratories across the campus. As Jain and colleagues (2009) observed, scientists often hold and express negative attitudes towards entrepreneurship based on a philosophical or professional aversion to commercial values. Alternatively, scientists may refrain from and discourage entrepreneurial activity based on negative entrepreneurial experiences that they or others have had in the past (e.g., getting "burned" by someone in the commercialization process), including negative experiences based on scientists' interactions with the university's own technology transfer policies. For example, as Owen-Smith and Powell (2001) have observed, "inconvenient or frustrating interactions with TTOs may be enough to convince ambivalent inventors that the benefits of IP protection do not outweigh the costs" (p. 112).

Accordingly, practitioners seeking to promote academic entrepreneurship must spend time talking directly with scientists across a range of disciplines and career levels. These communications should be repeated, face-to-face interactions in which practitioners ask questions of scientists and listen to their concerns. Through these interactions, practitioners can develop a more realistic, intimate understanding of how scientists really think about academic entrepreneurship, and this, as we explain further below, can inform the formulation and communication of commercialization policies. Moreover, such interactions can foster scientists' confidence in and curiosity about the commercialization process, and this is valuable because messaging intended to respond to or change scientists' attitudes about entrepreneurial activity will be more effective to the extent it is supported by norms that scientists themselves impart through their own behaviors and informal communications with peers. Thus, small-scale retreats or brownbag discussions that scientists themselves organize and lead for the benefit of their peers are likely to be at least as effective in

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shaping other scientists' attitudes and norms as are larger, more formal programs organized by administrators. This may be especially true for PhDs and postdoctoral researchers who, being earlier in their careers, may have more malleable attitudes.

Outside Perspectives

One experienced practitioner we know of has described hosting a series of informal dinners for scientists. These dinners are ostensibly organized around a speaker who is asked to shed light on a particular aspect of technology commercialization. But, this practitioner observed, "I typically leave before the scientists do, and a key goal for me is simply to have the scientists talk among themselves and create their own academic sub-community within which they can develop and share entrepreneurial norms."

Other formats can engage non-university stakeholders as well. For example, in a "reverse pitch," representatives of established companies can present innovation-related challenges to an audience that includes university-based scientists. Audience members are then given the opportunity to ask questions and propose solutions. Exchanges of this kind can stimulate conversations, research initiatives and partnerships that can further entrepreneurial outcomes. In addition, such exchanges can stimulate scientists to formulate attitudes and beliefs that are conducive to the formation of entrepreneurial intentions. For example, a well-executed reverse pitch is likely to strengthen scientists' impressions that commercializing inventions represents a feasible, consequential and rewarding extension of their traditional roles.

Clearing up Misconceptions

Second, given the extent to which evidence suggests that perceived behavioral control is important in this context, practitioners should look for ways to foster this sense of control among university-based scientists. At the most basic level, this involves ensuring that scientists have an accurate understanding of the specific behaviors they may perform in the process of commercializing their technologies. As Bandura (1997) observed:

"[people] typically consider certain occupational pursuits and stay clear of others based on their conceptions of occupations, which may be accurate or fanciful. They act on their conceptions even though those conceptions may involve misbeliefs about the actual skill requirements of the occupations." (p. 423)

Thus, scientists are liable to formulate erroneous conceptions of the skill requirements for academic entrepreneurship. For example, their conceptions of academic entrepreneurship may be based on more general conceptions they hold about what entrepreneurial activity entails, and those beliefs in turn may be shaped by observations drawn from personal experience or general media sources. However, participation in academic entrepreneurship is not identical to entrepreneurship in other contexts; the actual skills required of scientists in connection with many instances of technology commercialization (e.g., through licensing arrangements managed by the university's technology transfer office) are often much narrower and more limited than what one might infer based on an episode of the TV show "Shark Tank". Thus, practitioners should strive to define as specifically as possible the behaviors they would like to see scientists adopt, and they should be sure to clarify the range of behaviors associated with different paths of entrepreneurial activity (e.g., through licensing vs. startups).

Detailed discussions of specific roles within any given pathway are also likely to help scientists choose their own roles more carefully and to understand the complementary roles that others may need to play to improve the odds of commercializing an invention. For example, some scientists aspire to become CEOs of startups in situations where most experienced counselors or investors would advise them not to hold that role. Helping scientists understand the value of a new venture team and of alternative, non-CEO roles for which faculty are often better suited (e.g., Chief Scientific Officer) can help scientists to formulate more realistic conceptions of their own roles and, thereby, may help prevent negative commercialization experiences before they unfold.

In summary, perceived behavioral control in this context should not necessarily equate to "entrepreneurial self-efficacy" or other, similarly general and comprehensive conceptions of entrepreneurial ability. Moreover, interventions designed to cultivate scientists' sense of entrepreneurial efficacy should highlight the ways in which academic entrepreneurship can involve relatively accessible extensions and variations of the skills scientists already possess.

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Promoting Involvement

Proceeding from these observations, one can see how promoting scientist involvement in programs such as the National Science Foundation's Innovation Corps ("I-Corps") program in the U.S. may facilitate entrepreneurial behavior through multiple pathways. The I-Corps program provides innovation and product identification training at over 100 university sites across the country, which means that this program not only gives scientists training, but also shows social adoption of entrepreneurship by a well-respected scientific organization and the associated scientific community. The program also provides those involved at any given site with resources and an academic entrepreneurial community. Thus, programs like this – which work directly with scientists on their own concerns – have the potential to affect scientists' attitudes and perceived behavioral control as well as their perceptions of social norms.

Third, Bandura (1997) has long suggested that vicarious learning is a path to increased self-efficacy. Specifically, he suggests that seeing others perform a difficult task without experiencing negative consequences, or perhaps even experiencing positive consequences, leads others to believe that they themselves could perform the task. For practitioners, this suggests the importance of "telling stories" about academic entrepreneurship that profile the entrepreneurial "journeys" of individual scientists. For example, when successful academic entrepreneurs share their stories, either in person or through various media, they can act as "expanders" and mentors to other scientists who may still harbor doubts about entrepreneurial activities. In their 2009 book, Inventing Entrepreneurs, Gerry George and Adam Bock provide many examples of such journeys and provide frameworks for charting the alternative professional trajectories scientists can follow. Bear in mind that the extent to which vicarious experience increases a person's self-efficacy depends, to some extent, on social comparison. Therefore, whenever possible, practitioners should take care to assemble and display stories that document a range of different success stories, such as stories that portray the journeys of scientists at different stages in their respective careers.

Formal training in entrepreneurship may be another path to increased self-efficacy in this domain. For example, MIT Sloan offers a five-day entrepreneurship development program that introduces participants to the school's entrepreneurial support systems, such as the technology transfer system and its global entrepreneurial network. The program also covers the venture creation process from the idea generation stage all the way to scaling the business. Although this course is not specifically aimed at academic entrepreneurs, practitioners could offer versions of such a course that focus specifically on the support systems and processes of venture creation at their respective schools. This should both help entrepreneurs understand the process and reduce anxiety and confusion.

Matching Roles with Goals

Finally, practitioners should ensure that efforts to induce scientists' participation in academic entrepreneurship are matched to the actual goals and scientists that scientists possess while, at the same time, recognizing that their goals and values may vary. As Lam (2011) observed, although some scientists are indeed motivated by financial rewards ("gold", in her framework), others are motivated by "puzzles" (i.e., the intrinsic satisfaction of solving a customer's problem or having an impact) or "ribbons" (i.e., the reputational or career rewards associated with achieving commercial success). Without understanding a given scientist's motivation, persuasion attempts of any kind may fall on deaf ears.

It has been shown that university policies that diminish scientists' participation in the financial rewards of their inventions have the effect of discouraging scientists' entrepreneurial activity (Hvide & Jones, 2018), so practitioners are correct to anticipate that financial incentives matter for many faculty. At the same time, however, some scientists may be assign more importance than others to the knowledge that entrepreneurial behavior is compatible with their scientific scholarly goals, while others might be persuaded by the knowledge that they can increase funding for their lab or graduate students. Technology transfer officers will be better able to induce entrepreneurial behavior to the extent they can craft their messages to the range and mix of goals that scientists exhibit in their institutions. In fact, the resources described above (i.e., by Lam and by George and Bock) contain scales, exercises, and cases that practitioners may utilize in working with scientists.

CONCLUSION

Our hope is that this article has helped illustrate the value of placing the literature on academic

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entrepreneurship within a theoretical framework. We believe that this approach not only helps to clarify some of the most recent findings on academic entrepreneurship but also helps to organize the insights and implications that can be garnered from these findings. Moreover, we hope that practitioners can use our suggestions as a starting point for measuring, tracking, and changing cultures and practices at their own universities and in their own departments in ways that enable more scientists to participate in the commercialization of the inventions to which they devote their careers. Doing so, we believe, has the potential to enrich the world with innovations that improve the lives of people around the world while, at the same time, advancing the goals of researchers themselves and the universities they serve.

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