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Academic entrepreneurship: Which inventors do technology licensing officers prefer for spinoffs?

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Abstract Technology licensing officers play an important role in the creation of university spinoffs. Anecdotal data suggests that licensing officers make use of the representativeness heuristic when deciding which inventors' technologies should (not) be commercialized through the founding of new companies. In this context, use of the representativeness heuristic implies that licensing officers favor for spinoff creation the inventions of academics that "fit" the profile of a typical inventor-entrepreneur. To examine this possibility, we conduct a randomized experiment with more than 200 technology licensing officers at U.S. universities and find evidence consistent with the use of the representativeness heuristic.

Keywords University spinoffs · Entrepreneurship · Technology licensing offices · University inventions · Technology commercialization

JEL Classification L26 · M13 · O31 · O32

1 Introduction

The rapid rate of growth in spinoff company creation over the past 40 years (Thursby and Thursby 2007; Astebro et al. 2012) and the large economic impact of university spinoffs

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like Google, Cirrus Logic and Genentech (Shane 2004), has led researchers to explore the question: Why are university inventions sometimes exploited through the formation of spinoff companies and other times not?

A large literature on the factors that account for the formation of spinoff companies has emerged, with researchers providing evidence of the effect of the nature of the technology that has been developed (Shane 2001a; Pressman 2002; Shane 2004), the industry in which the technology would be exploited (Shane 2002, 2001b), the university in which the invention was created (Di Gregorio and Shane 2003; Shane 2004; Zhang 2009; Astebro et al. 2012), and the characteristics of the inventors that have come up with the invention (Levin and Stephan 1991; Roberts 1991; Zucker et al. 1998; Shane and Khurana 2003; Astebro et al. 2012).

Despite the widespread effort to explain why some university inventions result in the creation of spinoff companies and others do not, researchers have not examined one important factor: the greater willingness of technology licensing officers to support spinoff company formation by inventors with certain characteristics. This omission is surprising because the property rights to inventions made by faculty, staff and students belong to the institutions where these inventions were developed. As a result, technology licensing officers play an important role deciding how university inventions are commercialized (Thursby and Thursby 2002; Siegel et al. 2003, 2004; Owen-Smith and Powell 2003; Clarysse et al. 2005; Agrawal 2006).

When people make decisions under uncertainty, they often make use of the representativeness heuristic, a tendency to make choices on the basis of the similarity between a particular case and the typical example (Tversky and Kahneman 1974). In simple terms, the representativeness heuristic means people tend to favor those examples which look like the standard case and not favor it when it looks dissimilar (Kahneman and Tversky 1973).

Because licensing officers are people making decisions under uncertainty, they are likely to use the representativeness heuristic when evaluating whether an inventor should start a spinoff to commercialize an invention. As a result, licensing officers tend to favor those cases where the inventor matches the profile of a "typical" spinoff company founder, and are less likely to favor the cases where the inventor deviates from the standard profile.

Studies show that spinoff company founders are typically male immigrants with industry experience who are easy to work with (Shane 2004, 2005). Given the collective sense of what the "typical" spinoff company founder looks like, the representativeness heuristic suggests that licensing officers will favor 'easy-to-work-with' male immigrant academics with industry experience for start-up company formation. To date, no study has explored whether licensing officers follow the patterns predicted by the representativeness heuristic when deciding whether to support spinoff company formation.

To explore whether they do, we conducted an experiment with 239 technology licensing officers at 87 U.S. research universities in 2011. The licensing officers were asked to evaluate identical invention disclosures, to which we randomly assigned different inventor characteristics to predict two measures of licensing officers' willingness to support spinoff company creation. First, would the licensing officer try to dissuade the inventor from starting a company to commercialize this technology? Second, would the licensing officer recommend a startup that exploited this invention to the university's internal venture capital fund?

We conducted an experiment to examine our research question because observational data cannot address it. Other, unobserved inventor characteristics may be correlated with those that representativeness heuristic suggests would motivate licensing officers to favor certain inventors for spinoff companies. In observational data, any statistical association

between the examined inventor characteristics and the tendency of university licensing officers to favor particular inventions for spinoffs could be an artifact of these unobserved characteristics. To evaluate whether technology licensing officers offer less support for the formation of spinoff companies inventors with certain characteristics, researchers need to use an experimental design in which all factors other than licensing officer perceptions of those characteristics are controlled.

Our experiment shows statistically significant differences in the rate at which the licensing officers recommend spinoff company creation, depending on whether the inventor has characteristics (that previous studies indicate) that licensing officers believe are related to spinoff company creation. From these results, we conclude that licensing officers are influenced by inventor characteristics when making decisions about spinoff company creation, consistent with the representativeness heuristic.

We focus on licensing officer support for spinoff companies, rather than licensing to established businesses, for three reasons. First, much federal and state government policy in the United States is focused on the creation of spinoff companies rather than licensing university inventions to established companies. As a result, many academic administrators and policy makers are eager to know what factors affect the willingness of university licensing officers to support the formation of spinoff companies. Second, the available evidence (e.g., Shane 2004) indicates that the major source of the financial returns that universities have generated from their technology commercialization efforts comes from the equity holdings these universities have in their spinoff companies. Therefore, we seek to explain what factors lead licensing officers to support this type of commercialization effort. Third, licensing officers need to provide much more support to university spinoff company licensees than to large, established company licensees. For this reason, understanding the factors that affect licensing officer support for spinoff companies is important to the effective management of university technology licensing offices.

Our findings are important to researchers and practitioners in several ways. First, they provide insight into the influence that inventor attributes have on the creation of university spinoffs, rebalancing the literature's focus on the attributes of the inventions themselves. Second, they help us to better understand the decisions of technology licensing officers about university inventions, providing insight into how these individuals influence the process of technology commercialization (Shane 2004; Siegel et al. 2007). Third, this study serves to identify the support that licensing officers are willing to give particular types of inventors, suggesting attributes that will help inventors to increase their odds of founding a spinoff. Fourth, our study provides evidence of the use of the representativeness heuristic in a setting in which it has not previously been explored.

2 Literature review

The existing literature on spinoff company formation provides insight into many factors that affect the odds that a university invention will be exploited through the formation of a spinoff company, such as the nature of the technology, the industry in which the technology would be exploited, the university in which the invention was developed and the characteristics of the inventors that have come up with the new technology.

Researchers have shown that the nature of the technology that has been developed affects the odds that a new company will be founded to exploit an invention (Shane 2001a). Studies show that more important, generic, disruptive, early stage inventions with stronger patent protection are more likely than other inventions to result in the formation of spinoff

companies (Pressman 2002; Shane 2004). In addition, those technologies that would be exploited in industries that are favorable to start-up companies are also more likely to result in the formation of spinoffs than other inventions (Shane 2001b, 2002).

The university at which the invention was developed also affects the odds that a spinoff company will be founded. Institutions that distribute a smaller share royalty income to inventors are more likely to have spinoff companies, as are those institutions willing to make equity investments in the companies founded by faculty, staff and students (Di Gregorio and Shane 2003). Institutions that permit their faculty members to use university facilities for the development of spinoff companies and those with attractive leave of absence policies have more spinoff companies (Shane 2004). Universities with higher levels of research funding (Zhang 2009), greater research quality (Di Gregorio and Shane 2003; Zhang 2009; Astebro et al. 2012), higher prestige (Sine et al. 2003), and more programs to support entrepreneurship education also have more spinoffs (Astebro et al. 2012).

Other researchers have shown that the characteristics of the inventors themselves affect the odds that spinoffs will be formed. Studies show that the inventors' demographics (Astebro et al. 2012), career experience (Stephan and Levin 1991; Shane and Khurana 2003), psychological attributes (Roberts 1991), and research skills (Zucker et al. 1998) all affect spinoff company formation.

Despite this widespread effort to explain why some university inventions result in the creation of spinoff companies and others do not, one important factor has been overlooked: the process through which technology licensing officers evaluate university inventions. In particular, prior work has not considered whether and how licensing officers' views about what typical inventor-entrepreneurs tend to "look like" shape which inventions are exploited through creating spinoff companies.

This omission is surprising given the general understanding of the important role that technology licensing offices play in the commercialization of university inventions (Thursby and Thursby 2002; Siegel et al. 2003, 2004; Owen-Smith and Powell 2003; Clarysse et al. 2005; Agrawal 2006). Because the property rights to inventions made by faculty, staff and students belong to the institutions where these inventions were developed (Thursby et al. 2001), technology licensing officers influence whether or not university inventions are licensed, and, if they are, whether the invention is licensed to an established business or to an entrepreneur founding a spinoff company.

After an academic inventor discloses his or her invention to the university, technology licensing officers evaluate whether the invention should be patented, and, if so, what mode of commercialization would be most appropriate for it (Jensen et al. 2003; Shane 2004). Since technology licensing offices are time and resource-constrained, and not all inventions have sufficient potential to justify the allocation of resources to their development, licensing officers support only a limited number of inventions for commercialization (Shane 2001a; Jensen et al. 2003; Vohora et al. 2004). When licensing officers decide on whether and how an invention should be commercialized, they apply selection criteria (Roberts and Malone 1996; Owen-Smith and Powell 2001) to choose between inventions—typically considering the characteristics of the invention, the market in which the technology would be exploited, the university's policies, and the attributes of the inventor disclosing it (Shane 2004; Vohora et al. 2004; Clarysse et al. 2005).

The choice of which early-stage technological inventions to support for commercialization is not simple, given that their commercial potential, possible applications, and target markets are largely unknown at the time of evaluation (Shane 2000; Jensen and Thursby 2001; Dechenaux et al. 2008; Markman et al. 2008).

Given this uncertainty, the decision making procedures of technology licensing officers are not formulaic. Rather, licensing officers have considerable discretion in deciding whether and how to support the formation of a spinoff company as the mode of exploitation (Shane 2004; Vohora et al. 2004; Clarysse et al. 2005).

Behavioral economists have shown that when people make decisions under uncertainty, and are subject to time and resource constraints, they often make use of biases and heuristics (Tversky and Kahneman 1974). According to Tversky and Kahneman (1974, p. 1124) heuristic principles "reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations". One of the most notable decision making heuristics is the representativeness heuristic, where people make choices by looking at how similar a particular case is to the typical example (Kahneman and Tversky 1973). In simple terms, the representativeness heuristic means that people tend to favor cases that look like the standard example and disfavor cases that look dissimilar.

We posit that licensing officers, perhaps unconsciously, make use of the representativeness heuristic when deciding about whether an inventor should start a spinoff to commercialize an invention. Use of this heuristic leads licensing officers to favor for spinoff creation those cases where the inventor fits the standard profile of a university inventor-entrepreneur and are less likely to favor spinoff creation when the inventor deviates from the standard profile.

Previous studies show that (licensing officers think that) the typical inventor-entrepreneur is a male immigrant who has industry experience and is easy to work with (Franklin et al. 2001; Stephan and Levin 2001; Shane 2004; Vohora et al. 2004; Bunker Whittington and Smith-Doerr 2005; Shane 2005; Hunt 2009). Because prior research shows that (licensing officers believe that) these attributes are key characteristics of the typical inventor-entrepreneur, we expect that they would trigger the representativeness heuristic. That, in turn, implies that licensing officers favor inventors with these characteristics for founding spinoffs.[1]

Below we develop specific hypotheses about how the representativeness heuristic leads technology licensing officers to favor for spinoff company creation the inventions of academics with the characteristics of typical inventor-entrepreneurs.

2.1 The male inventor-entrepreneur

The representativeness heuristic leads technology licensing officers to favor the inventions of male academics for spinoff company creation. Female academics are less likely than their male counterparts to engage in the commercialization of science (Bunker Whittington and Smith-Doerr 2005; Ding et al. 2006), whether that commercialization is measured by number of invention disclosures (Thursby and Thursby (2005), patents (Bunker Whittington and Smith-Doerr 2005; Ding et al. 2006; Azoulay et al. 2007), licenses (Link et al. 2007), or start-up companies (Bunker Whittington and Smith-Doerr 2005; Ding et al. 2006; Murray and Graham 2007).

Researchers have offered several explanations for the gender gap in the entrepreneurial activity of scientists (Murray and Graham 2007; Stephan and El-Ganainy 2007). Some observers have argued that male and female faculty members differ in their interests and expertise, and that these differences affect the probability that they start spinoff companies.

[1] Licensing officers may consider other attributes. However, we do not yet have (any initial) evidence that other attributes may serve as key characteristics of inventor-entrepreneurs which might trigger the representativeness heuristic in licensing officer decisions making.

Among the key differences that researchers have identified are attitudes toward risk, views of competition, social networks, views of money, research foci, and personal and professional responsibilities, all of which influence the willingness of academics to found spinoff companies (Murray and Graham 2007; Ding et al. 2006; Stephan and El-Ganainy 2007). In addition, female faculty members are less likely to start intellectual property based companies, tending instead to found businesses based on their non-IP-based research knowledge (Fini et al. 2010). The gender-based differences in interests result in lower odds that female faculty members will start spinoff companies in comparison to their male counterparts.

Differences in the way that technology licensing officers perceive the odds that male and female faculty members start spin-off companies affect their willingness to offer entrepreneurial opportunities to female faculty members (Murray and Graham 2007; Stephan and El-Ganainy 2007). For instance, if university technology licensing officers believe that the research of female faculty members is of lesser quality than that of male faculty members, or that the inventions of male academics have greater commercial potential, then they may be less supportive of female academics creating spinoff companies. In addition, if licensing officers believe that the inventions of female faculty members are less appropriate for spinoff companies than those of their male counterparts, female faculty members may receive fewer resources or less institutional support for the formation of spinoff companies (Long and Fox 1995; Fox 2001; Bunker Whittington and Smith-Doerr 2005).

Regardless of the specific explanations that licensing officers give for their differential support for spinoff company creation by male and female academics, any resulting variation in support is likely influenced by decision making based on the representativeness heuristic. Because male academics are more likely to start spinoff companies, licensing officers perceive them as the more typical inventor-entrepreneurs. As a result, licensing officers will be less willing to support the efforts of female academics to start spinoff companies in comparison to their male counterparts (Murray and Graham 2007). This argument leads to the following hypothesis:

H1 Technology licensing officers favor the inventions of male faculty members over the inventions of female faculty members for the creation of spinoff companies.

2.2 The immigrant inventor-entrepreneur

The representativeness heuristic leads technology licensing officers to favor the inventions of immigrant academics for spinoff company creation. Research shows that immigrant faculty members are more likely than other faculty members to commercialize their research by starting companies (Stephan and Levin 2001; Hunt 2009). For instance, Stephan and Levin (2001) show that foreign-born researchers are disproportionately overrepresented among the academics that played a key role in launching biotechnology firms. Krabel et al. (2012) find that faculty members who are foreign-born and educated are more likely to start companies than native-born faculty members.

Licensing officers may perceive that immigrant inventors are more likely to start spinoff companies than native born inventors for many different reasons. Licensing officers may believe that immigrant faculty members are more likely to start spinoffs because they are more motivated than native born faculty members, because of the personal sacrifices they have made to emigrate (Stephan and Levin 2001), because they are more productive (Lee 2004; Corley and Sabharwal 2007), or because they possess broader skills and social

capital as a result of their mobility (Krabel et al. 2012). Alternatively, they may perceive immigrant faculty members to be more creative and entrepreneurial because of the selection processes inherent in the visa system (Hunt 2009) or because their backgrounds make them more likely to identify entrepreneurial opportunities (Saxenian 2002).

Irrespective of these underlying reasons, the representativeness heuristic implies that licensing officers perceive immigrant inventors as the more typical inventor-entrepreneurs because they are more likely to start spinoff companies. As a result, licensing officers will be more willing to support the efforts of immigrant academics to start spinoff companies in comparison to their native born counterparts. These arguments lead to our second hypothesis:

H2 Technology licensing officers favor the inventions of immigrant faculty members over the inventions of native faculty members for the creation of spinoff companies.

2.3 The industry experienced inventor-entrepreneur

The representativeness heuristic also leads technology licensing officers to favor the inventions of industry-experienced academics for spinoff company creation. Prior research indicates that faculty members with ties to investors or business, or industry experience, are more likely to engage in spinoff activity. Landry et al. (2006) show that the likelihood of launching a university spinoff increases if a researcher has consulting experience. In addition, they find that the intensity of the researcher's linkages with private sector professionals increases the probability of spinoff creation. Similarly, Krabel and Mueller (2009) find that faculty members with close ties to industry, in the form of experience in research cooperation with private firms, are more likely to found a spinoff company.

Licensing officers are aware of these patterns and may perceive industry-experienced inventors as more likely to be inventor-entrepreneurs than other inventors for a variety of reasons. They may think that academics need information and expertise from the business world to commercialize their inventions, (Landry et al. 2006). They may believe that industry experience helps academics to understand the difference between business and academia, and gives them useful skills for starting companies (Shane 2004; Mosey et al. 2006). Alternatively, they may think that industry experience provides insight into the workings of the industry in which the invention would be applied, helps to position a spinoff appropriately within that industry, and gives the founders information about potential customers (Shane 2004, 2005). Technology licensing officers may believe that by interacting with industry, faculty members gain a network of potential suppliers, customers and investors (Roberts and Malone 1996; Shane and Cable 2002; Shane 2004) that is helpful for starting a company (Grandi and Grimaldi 2003; Nicolaou and Birley 2003; Grandi and Grimaldi 2005; Mosey et al. 2006) or that academic entrepreneurs without industry experience concentrate too much on technical issues at the expense of commercial ones (Daniels and Hofer 1993; Franklin et al. 2001; Vohora et al. 2004).

When licensing officers give differential support for spinoff company creation in view of the inventor's (lack of) industry experience, such variation in assistance is likely influenced by decision making based on the representativeness heuristic. Because industry-experienced academics are more likely to start spinoff companies, licensing officers perceive them as the more typical inventor-entrepreneurs. As a result, licensing officers will be more willing to support the efforts of industry-experienced academics to start spinoff companies in comparison to their less experienced counterparts. These arguments lead to our third hypothesis:

H3 Technology licensing officers favor the inventions of faculty members with industry experience over the inventions of faculty members without industry experience for the creation of spinoff companies.

2.4 The easy-to-work-with inventor-entrepreneur

Finally, the representativeness heuristic leads technology licensing officers to favor the inventions of academics who are (perceived to be) easy to work with. Interviews with technology licensing office directors indicate that they find faculty members who are easy to work with to be more appropriate for creating spinoff companies (Shane 2005).

Licensing officers may form these perceptions for a variety of reasons. Because faculty members need to work with many different actors, including investors, suppliers and customers to create a university spinoff (Mustar 1997; Walter et al. 2006), licensing officers may think that faculty members who are difficult to work with could have problems in raising money, attracting suppliers, and finding employees, because external stakeholders may choose to avoid such inventors (Shane 2005) or because faculty members are reluctant or unable to interact and develop needed relationships with others (Mosey et al. 2006; Mustar et al. 2008).

Licensing officers may believe that inventors with stronger social skills are more likely to be successful at starting companies than inventors with weaker social skills (Baron and Markman 2000, 2003), because the ability to interact effectively with others facilitates new business formation (Stuart and Abetti 1987; Duchesneau and Gartner 1990). Licensing officers may view this ability to interact with others as typical to inventor-entrepreneurs (Grandi and Grimaldi 2003; Nicolaou and Birley 2003; Mosey and Wright 2007; Rasmussen et al. 2011). The inventions that form the basis for university spinoffs are usually in very early stages of development and highly uncertain inventors often have valuable tacit knowledge, so their engagement is required to further develop the technology (Agrawal 2006).

Licensing officers may see the value of social skills, such as the tendency to react clearly, engender positive feelings, make favorable impressions, and induce cooperation in others (Fligstein 2001; Ferris et al. 2001; Baron and Markman 2003; Harris et al. 2007)—skills which have been found to enhance success in the business environment (Ferris et al. 2002a, b; Witt and Ferris 2003; Riggio and Lee 2007; Riggio and Reichard 2008), particularly in an entrepreneurial context (Baron and Markman 2000). Licensing officers may believe that social skills help entrepreneurs to build and expand their personal networks, facilitate access to information and resources and enhance the quality and outcome of interaction with others (Baron and Markman 2000, 2003; Baron and Tang 2009).

Whatever specific explanation licensing officers give for their differential support for spinoff company creation by academics who are easy to get along with, the variation in assistance is influenced by decision making based on the representativeness heuristic. Because academics who are easy to work with are more likely to start spinoff companies, licensing officers perceive them as more likely to be the "inventor-entrepreneur" type. As a result, licensing officers will be more willing to support their efforts to start spinoff companies in comparison to their counterparts who are more difficult to work with. These arguments lead to the fourth hypothesis:

H4 Technology licensing officers favor the inventions of faculty members who are easy to work with over the inventions of faculty members who are difficult to work with for the creation of spinoff companies.

3 Method

Previous studies have mainly relied on anecdotal data to suggest that technology licensing officers are influenced by inventor characteristics. However, the use of observational data to address this question is problematic, as the example of higher rates of spinoff company formation by immigrant faculty members suggests. Immigrant academics may just be higher in number, or in a different period of the academic-life-cycle (and driven by a different set of incentives), or not equally distributed across research disciplines (e.g., Indian and Chinese ethnicities may be overrepresented in engineering and biotechnology) from non-immigrant academics. Alternatively, immigrant faculty members may be more proactive in disclosing their technologies, or less likely to trade off research time for administrative or teaching duties.

To establish a causal relationship between inventor characteristics and the degree of support that technology licensing officers give to spinoff creation, one needs to conduct a randomized experiment in which the hypothesized inventor characteristics are randomly assigned to the same invention disclosures.

3.1 Sample

To obtain subjects for the study, we contacted the technology licensing office directors at 223 Carnegie I research universities in the United States and asked their offices to participate in the study. All offices that agreed to participate would receive a $50 gift card to provide a meal or coffee for their licensing officers as a token of our gratitude. Of the 223 offices contacted, 98 agreed to participate. At the offices that agreed to participate, we asked the licensing office director for the number of licensing professionals at their institution and the name and email address of those licensing officers.

We invited 352 licensing officers to participate in the experiment, which was conducted online. We sent each participant an email that included a password-protected link to the online experiment accompanied by a unique login code and password combination to gain access to the experiment. The unique login information ensured confidentiality of both the invention disclosures and the licensing officers' responses. Participants were required to complete the entire experiment in a single session and were not able to modify or complete their answers at a later point in time. After sending out the invitations and several reminders, 239 licensing officers from 87 offices completed the experiment (giving a response rate of 67.9 %). No statistically significant differences existed between those that participated and those that did not on whether they received the experimental or control treatment.

The sample of licensing officers included 155 male (64.9 %) and 84 female licensing officers (35.1 %), ranging in age from 25 to 78 years ($M = 43.9$). On average, the participants had been working 6.9 years as a university technology licensing officer. In terms of highest level of education, 105 licensing officers hold a PhD (43.9 %), 108 hold a Master's degree (45.2 %) and 24 hold a Bachelor's degree (10.0 %). (Two licensing officers hold an Associates degree.) In terms of educational background, 104 licensing officers obtained their highest degree in life sciences (38.4 %), 49 in engineering (18.1 %), 44 in business (16.2 %), 27 in law (10.0 %), 24 in chemistry (8.9 %), 6 in computer science (2.2 %) and 17 licensing officers obtained their degree in other fields (6.3 %).

3.2 Treatments and comparison of treatment and control groups

Each licensing officer was asked to look at four invention disclosures, one to examine each "typical" inventor-entrepreneur characteristic: male, immigrant, with industry experience, and easy to work with. For each disclosure, we randomly assigned licensing officers to the treatment or control groups. Except for the specific treatment, both the treatment and control groups received identical invention disclosures and inventor descriptions. Our experiment included the following treatments and controls:

3.2.1 The male inventor-entrepreneur

The treatment group received a disclosure with a male name and male picture, while the control group received an invention disclosure with a female name and female picture.

3.2.2 The immigrant-entrepreneur

The treatment group received a disclosure with a Chinese name and Asian picture, while the control group received an invention disclosure with an American name and Caucasian picture. We chose to operationalize immigrant scientists as scientists with a Chinese name and Asian picture because our experiment only allows for testing one type of immigrant scientist. Asian scientists make up the largest part of the foreign-born scientist population in the United States (Corley and Sabharwal 2007; Lin et al. 2008) and Chinese scientists are the largest ethnic contributor to U.S. domestic and international patent applications (Wadhwa et al. 2007; Kerr 2008).

3.2.3 The industry experienced inventor-entrepreneur

The treatment group received a disclosure where the inventor had industry experience. The control group received a disclosure where the inventor clearly had no industry experience.

3.2.4 The easy-to-work-with inventor-entrepreneur

The treatment group received a disclosure with the description of an inventor who is easy to work with. The control group received a disclosure with the description of an inventor who is difficult to work with.

To check the random assignment of licensing officers to treatment and control groups, we compared the treatment and control groups on the following licensing officer characteristics: age, experience, gender, technical field, and highest academic degree. As one would expect from a random assignment, there are only small, non-significant differences between the treatment and control groups. Table 1 shows the means, standard deviations, and t-tests for the check of randomization.

3.3 The invention disclosure

The invention disclosures were modified from actual university invention disclosures submitted at the first author's university. A university invention disclosure form typically includes the name of the inventor or inventors; their positions at the university; the title of the invention; a summary of the invention, including an explanation of why it is an improvement over existing technologies, along with any supporting charts, graphs, or

Table 1 Check of the randomization

Treatments	Male	Female	American-named	Chinese-named	Industry experience	No industry experience	Difficult to work with	Easy to work with
N	119	120	123	116	121	118	122	117
TLO characteristics								
Gender	1.39 (0.49)	1.32 (0.47)	1.31 (0.46)	1.40 (0.49)	1.39 (0.49)	1.31 (0.46)	1.30 (0.46)	1.41 (0.49)
t value		1.13		1.42		1.31		1.87
Age	43.29 (12.55)	44.43 (11.55)	45.00 (10.90)	42.66 (13.09)	43.08 (10.63)	44.65 (13.33)	44.09 (11.98)	43.62 (12.16)
t value		0.74		1.51		1.00		0.3
Experience	6.97 (5.46)	6.87 (4.80)	7.20 (5.48)	6.61 (4.73)	6.93 (5.32)	6.90 (4.94)	6.70 (5.03)	7.14 (5.25)
t value		0.15		1.52		0.05		0.65
Education	2.27 (0.72)	2.38 (0.65)	2.38 (0.67)	2.26 (0.70)	2.30 (0.71)	2.34 (0.67)	2.39 (0.65)	2.25 (0.72)
t value		1.2		1.39		0.50		1.64
Law or Business	0.28 (0.45)	0.31 (0.46)	0.30 (0.46)	0.28 (0.45)	0.31 (0.47)	0.27 (0.45)	0.28 (0.45)	0.31 (0.46)
t value		0.53		0.28		0.73		0.49
Engineering	0.20 (0.40)	0.21 (0.41)	0.19 (0.39)	0.22 (0.42)	0.18 (0.38)	0.24 (0.43)	0.20 (0.41)	0.21 (0.41)
t value		0.13		0.71		1.15		0.00
Life sciences	0.49 (0.50)	0.38 (0.49)	0.47 (0.50)	0.40 (0.49)	0.51 (0.50)	0.36 (0.48)	0.48 (0.50)	0.39 (0.49)
t value		1.63		1.17		2.31*		1.28
Other	0.17 (0.38)	0.23 (0.42)	0.17 (0.38)	0.22 (0.42)	0.17 (0.37)	0.23 (0.42)	0.20 (0.40)	0.20 (0.40)
t value		1.11		1.04		1.23		0.00

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

pictures, sufficient to allow the technology licensing office to review the invention for patentability; a description of any efforts to reduce the invention to practice; an indication of what type of disclosure, if any, has been made on the invention; and a list of any entities that might be interested in licensing the invention.

The modification of the invention disclosures was done in conjunction with the director of the technology licensing office to ensure that the resulting texts were realistic and representative of the disclosures considered by university technology licensing officers. The first author's university did not participate in the main experiments of this study. Before administration, the experiment was pre-tested by licensing officers from the technology transfer office at that university to ensure that it was realistic, well understood, and could be completed in a reasonable amount of time.

3.4 Measures

In conjunction with the director of the technology licensing office at the first author's university, we designed two measures to capture licensing officers' evaluations of the invention disclosure as the basis for spinoff company creation. The measures were formulated to realistically reflect how licensing officers would express their support or lack of support for spinoff company creation. The two measures were designed to capture positive as well as negative approaches to spinoff creation and were both measured on a five-point Likert scale. The first measure asks, "If the inventor wanted to start a company to commercialize this technology, how much would you try to dissuade the inventor?" (1 = *not at all*, 5 = *as much as I could*). The second asks, "How likely would you be to recommend a startup that exploited this invention to your university's internal venture capital fund?" (1 = *very unlikely*, 5 = *very likely*).

4 Results

The basic results of our study are presented in Table 2, which gives an overview of the expected and actual effects of our treatments. As Table 2 shows, our results indicate that all tested inventor characteristics influence technology licensing officer decision-making in ways consistent with our predictions. However, not all inventor characteristics significantly affected both dependent variables examined.

The results of our statistical analysis are presented in Table 3. Consistent with our predictions, the licensing officers who received the random assignment of a female

Table 2 Expected and actual effects of the treatments

Treatments (inventor characteristics)	Expected effects		Actual effects	
	Dissuade inventor from starting a company	Recommend to university venture capital fund	Dissuade inventor from starting a company	Recommend to university venture capital fund
Male	−	+	−**	
Chinese-named	−	+		+*
Industry experience	−	+	−****	+**
Easy to work with	−	+	−*	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

Table 3 Comparison of the experimental and control groups

Treatments (inventor characteristics)	N	Dissuade inventor from starting a company	*t* value	d^{a}	Recommend to university venture capital fund	*t* value	d^{a}
Male	119	2.09 (0.97)			3.55 (0.95)		
Female	120	2.53 (1.26)	3.03**	0.39	3.37 (0.95)	1.46	0.19
American-named	123	2.42 (1.09)			3.32 (0.97)		
Chinese-named	116	2.20 (1.19)	1.52	0.19	3.60 (0.92)	2.34*	0.30
Industry experience	121	2.02 (1.13)			3.09 (1.07)		
No industry experience	118	2.84 (1.34)	5.09****	0.67	2.72 (1.13)	2.60**	0.34
Easy to work with	117	2.75 (1.25)			2.38 (1.02)		
Difficult to work with	122	3.17 (1.40)	2.44*	0.32	2.30 (1.15)	0.52	0.07

Cohens' d effect size (*t* test difference in means): small ≥ 0.20, medium ≥ 0.50, large ≥ 0.80

t $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

[a] Cohen's *d* (Cohen 1988, 1992) as a measure of effect size, calculated using the pooled standard deviation: $d = \frac{|\bar{X}_1 - \bar{X}_2|}{\sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2}}}$

inventor were significantly more likely to dissuade the inventor from starting a company ($M = 2.53$, $SD = 1.26$), compared to the officers who received an invention disclosure with a male inventor ($M = 2.09$, $SD = 0.97$), $t(237) = 3.03$, $p = 0.0027$, Cohen's $d = 0.39$. However, there was no statistically significant difference in the recommendation of the start-up to the university's internal venture capital fund (female inventors $M = 3.37$, $SD = 0.95$; male inventors $M = 3.55$, $SD = 0.95$, $t(237) = 1.46$, $p = 0.1456$, Cohen's $d = 0.19$.)

We observed a statistically significant difference in recommendation of the invention to the university's internal venture capital fund based on the inventor's immigrant status. Licensing officers were more likely to recommend the inventions of Chinese-named Asian inventors ($M = 2.42$, $SD = 1.09$) to their university's venture capital fund compared to inventions of American-named Caucasian inventors ($M = 3.32$, $SD = 0.97$): $t(237) = 2.34$, $p = 0.0201$, Cohen's $d = 0.30$. But there was no statistically significant difference in the degree of dissuasion from starting a business between the treatment group receiving an Chinese-named Asian inventor ($M = 2.20$, $SD = 1.19$) and the control group receiving an American-named Caucasian inventor ($M = 2.42$, $SD = 1.09$): $t(237) = 1.52$, $p = 0.1298$, Cohen's $d = 0.19$.

We found that licensing officers were significantly less likely to dissuade inventors with industry experience from starting a company ($M = 2.02$, $SD = 1.13$) compared to inventors without industry experience ($M = 2.84$, $SD = 1.34$): $t(237) = 5.09$, $p = 0.0000$, Cohen's $d = 0.67$. Moreover, licensing officers were more likely to recommend inventions by inventors with industry experience ($M = 3.09$, $SD = 1.07$) to their university's venture capital fund, compared those of inventors without industry experience ($M = 2.72$, $SD = 1.13$): $t(237) = 2.60$, $p = 0.0099$, Cohen's $d = 0.34$.

Licensing officers were significantly less likely to dissuade inventors perceived as easy to work with ($M = 2.75$, $SD = 1.25$) from starting a company, compared to inventors who are difficult to work with ($M = 3.17$, $SD = 1.40$): $t(237) = 2.44$, $p = 0.0154$, Cohen's $d = 0.32$. However, we did not observe a statistically significant difference in the likelihood that licensing officers would recommend a spinoff to the university's internal venture capital fund between inventors who are easy to work with ($M = 2.38$, $SD = 1.02$) and inventors who are difficult to work with ($M = 2.30$, $SD = 1.15$): $t(237) = 0.52$, $p = 0.6035$, Cohen's $d = 0.07$.

4.1 Robustness checks

To confirm the robustness of the effects found, we ran ordinary least squares regression models to predict our two dependent variables with licensing officer characteristics as control variables. Each regression model included a treatment as the main predictor variable and licensing officer age, experience, gender, technical field, and highest degree as control variables. To account for the multilevel nature of our data (some licensing officers work at the same university), we clustered the standard errors by university. As Table 4 shows, the results are robust to the inclusion of these additional controls.

5 Discussion

Understanding technology licensing officers' decision making and how inventor characteristics influence their support for spinoff creation is critical to the theory and practice of academic spinoff creation (O'Shea et al. 2004, 2008; Link and Siegel 2005). While

Table 4 OLS regressions including licensing officer controls with robust standard errors (adjusted for university level clusters)

Model Dependent variable	I Dissuade Inventor	II Recom. for VC	III Dissuade inventor	IV Recom. for VC	V Dissuade inventor	VI Recom. for VC	VII Dissuade inventor	VIII Recom. for VC
Treatments[a]								
Male	−0.42** (0.16)	0.13 (0.12)						
Chinese-named			−0.20 (0.15)	0.27* (0.12)				
Industry experience					−0.81**** (0.15)	0.34* (0.15)		
Easy to work with							−0.37* (0.16)	0.03 (0.14)
TLO controls								
Gender (male TLO)	0.17 (0.16)	0.03 (0.14)	0.17 (0.17)	0.01 (0.14)	−0.16 (0.19)	0.43** (0.15)	−0.11 (0.17)	0.28 (0.15)
Age (in years)	0.01* (0.01)	−0.01* (0.01)	0.01* (0.01)	−0.01* (0.01)	0.01 (0.01)	−0.00 (0.01)	0.01 (0.1)	−0.01* (0.01)
Experience (in years)	−0.02 (0.02)	0.00 (0.01)	−0.02 (0.02)	0.01 (0.01)	−0.02 (0.02)	0.00 (0.01)	−0.01 (0.02)	0.01 (0.02)
Education[b]	0.07 (0.12)	−0.04 (0.12)	0.10 (0.12)	−0.04 (0.11)	−0.08 (0.14)	0.31* (0.12)	0.20 (0.16)	0.05 (0.13)
Law or business[c]	0.03 (0.15)	0.06 (0.17)	0.03 (0.15)	0.07 (0.17)	−0.29 (0.21)	0.09 (0.17)	−0.42 (0.23)	0.26 (0.20)
Engineering[c]	−0.34 (0.22)	0.43* (0.18)	−0.37 (0.23)	0.43* (0.18)	−0.31 (0.22)	0.38 (0.20)	−0.36 (0.24)	0.08 (0.19)
Life sciences[c]	−0.03 (0.20)	0.33* (0.16)	−0.11 (0.20)	0.36* (0.15)	0.19 (0.20)	−0.00 (0.16)	−0.18 (0.21)	0.04 (0.18)
Constant	1.73*** (0.51)	3.69**** (0.38)	1.40** (0.49)	3.86**** (0.38)	3.19**** (0.58)	1.49**** (0.36)	2.21**** (0.55)	2.22**** (0.45)
N	239	239	239	239	239	239	239	239
F value	3.16**	2.72*	2.02	2.80**	6.39****	4.92***	2.66*	1.20
R^2	0.08	0.06	0.05	0.08	0.13	0.10	0.08	0.04

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

[a] Dummy variable equal to 1 for treatment group

[b] Categorical variable representing highest education level licensing officer, 0 = Associate degree; 1 = BSc degree; 2 = MSc degree; 3 = PhD

[c] Dummy variable indicating whether the licensing officer's educational background includes this field

previous research suggests that inventor attributes influence the views of investors (Munari and Toschi 2011) and technology licensing officers (Shane 2004) about the appropriateness of spinoffs as a commercialization vehicle, our experiments provide evidence of the causal effect of inventor attributes. Technology licensing officers appear to engage the representativeness heuristic, favoring for spinoffs the inventions of those academics that "fit" the profile of typical inventor-entrepreneurs. Specifically, licensing officers are more positively disposed to spinoffs when the inventions are made by male, Chinese-named Asian inventors, as well as by inventors with industry experience and those perceived as easy to work with. Inventors with these attributes will be more likely to create spinoff companies than the characteristics of their inventions alone would suggest.

Our results help to explain how technology licensing officers' willingness to support certain types of inventors influences who starts spinoff companies. For example, our study indicates that the random assignment of a female faculty member to an invention disclosure makes licensing officers less likely to encourage the formation of a spinoff company. This suggests university licensing officers' greater willingness to support male inventors account for some of the underrepresentation of women among university spinoff founders. Any efforts to address the underrepresentation of women among spinoff company founders will therefore have to include interventions targeting the attitudes of technology licensing officers toward female founders of spinoffs.

Universities might not want to intervene to alter all of the licensing officers' tendencies to provide support to inventors with certain attributes, however. Consider the case of the inventor's industry experience. Our results indicate that licensing officers are more likely to recommend (for spinoff creation) invention disclosures submitted by inventors with industry experience. This pattern suggests that institutions interested in boosting their output of spinoff companies should motivate faculty members with no industry experience to team up with experienced entrepreneurs (at an early stage), hire faculty members with industry experience, or put in place programs that enhance the industry experience of faculty members, such as exchange programs with industry research laboratories and networking events (Nicolaou and Birley 2003). Moreover, our results underline the recommendation of those who have called for a more active role of technology licensing officers in facilitating industry interaction among academics lacking such connections as a way to encourage spinoff company creation (Nicolaou and Birley 2003; Vohora et al. 2004; Mustar et al. 2008). To this end, our findings support the creation and expansion of recent federal funding initiatives, such as the "NSF Innovation Corps Program", designed to establish academic-to-corporate partnerships that integrate graduate students, academic inventors and corporate/entrepreneurial mentors.

Our study has several limitations. First, its research design involves a randomized experiment that serves to examine the causal effect of inventor attributes on licensing officer support for spinoff creation, but also results in a stylized research setting. Although we took several measures to make the experiment as realistic as possible, the licensing officers were asked to conduct a simplified and time-constrained evaluation process in place of a more iterative multistage selection process (Shane 2004). Moreover, inventor attributes are typically not contained in the invention disclosure document. Therefore, our experimental design might have made a clearer association between those attributes and the invention itself than is normally the case when university licensing officers evaluate invention disclosures. While we have no evidence to suggest that the results obtained are an artifact of the stylized nature of the experiment, it is possible that the patterns observed were either over- or understated as a result of it.

Second, we operationalized immigrant inventors as Chinese. As a result, our measure confounds race and immigrant status and we cannot be sure which of the two characteristics accounts for the patterns we observe.

Third, for some treatments we found support for only one of the two outcome measures examined. These partial results might reflect differences in how licensing officers respond to inventor attributes when they are asked to take positive action (i.e., recommending a spinoff company to venture capital fund) or negative action (i.e., dissuading inventor from starting a spinoff company). They might also reflect differences between the situation when the spinoff has not yet been established (and individual characteristics matter relatively more) and when the spinoff has been established (and individual characteristics matter relatively less). Alternatively, the partial results may simply represent measurement error that comes from the imprecision of using scale scores to understand licensing officer recommendations.

Fourth, our findings may not be generalizable to technology transfer offices outside the US. Although we have no evidence to suggest that our results would not generalize to other countries, additional research would be needed to show that they would. Cultural differences, for instance, might lead licensing officers elsewhere to respond differently to the experimental treatments we employed.

Finally, our results would not necessarily generalize to licensing to established companies because different factors affect the willingness of university technology licensing officers to support the formation of spinoff companies from those that affect their willingness to support licensing to established companies. Because our paper focuses solely on spinoff company formation, we cannot comment on the factors that affect licensing officer support for licensing to established companies.

In short, technology licensing officers play an important role in influencing the commercialization of university inventions because they often make recommendations about which inventions should be commercialized through creating spinoff companies. The randomized experiment in this study points out that the characteristics of the inventors who disclose the inventions affect these recommendations. While licensing officer dispositions might be problematic or desirable (depending on how university officials and other stakeholders assess these dispositions), our results clearly demonstrate the direct effect of inventor attributes on licensing officer decisions about the commercialization of university technology by way of forming spinoff companies.

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