J Technol Transf (2012) 37:508–531
DOI 10.1007/s10961-010-9202-7

Conflict between entrepreneurship and open science, and the transition of scientific norms

Sotaro Shibayama

Published online: 3 November 2010

Abstract In the trend of academic entrepreneurship, practical and direct contribution of university research to the society has been emphasized, in which university scientists have increasingly engaged in commercial activities, university-industry relationships, and technology transfers. However, this trend has aroused concern about a potentially negative impact on the tradition of open science. Drawing on a survey data of 698 Japanese natural scientists, this study analyzes the behaviors and norms of university scientists under the influence of university interventions for entrepreneurship, whereby examining the compatibility between entrepreneurship and open science. The results indicate that entrepreneurial interventions have facilitated scientists' norm for practical contribution, and consequently, their involvement in commercial activities and ties with industry. Then, some, but not all, of these entrepreneurial activities have deterred cooperative or open relationships between scientists. However, the results suggest that the entrepreneurial interventions have not deteriorated the traditional norm for open science. Further analyses indicate that the two norms for practical contribution and for open science are determined independently, implying that academic entrepreneurship can be promoted without deteriorating open science.

Keywords Entrepreneurship · Academic capitalism · Commercialism · Open science · Scientific norm

JEL Classification I23 · O38

S. Shibayama (✉)
School of Public Policy, Georgia Institute of Technology, 685 Cherry Street, Atlanta, GA 30332-0345, USA
e-mail: shibayama@00.alumni.u-tokyo.ac.jp

S. Shibayama
Research Center for Advanced Science and Technology, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8904, Japan

S. Shibayama
National Institute of Science and Technology Policy (NISTEP), 3-2-2, Kasumigaseki, Chiyoda-ku, Tokyo 100-0013, Japan

1 Introduction

Since around the 1980s, policy makers and the science community have underscored the indispensable role of academic institutions in the innovation system (e.g., OECD 1999; National Academy of Sciences 1993), and greater emphasis was placed on the direct and practical contribution of university research to society. In this regime called academic entrepreneurship (or academic capitalism), university-industry relationships (UIRs) and commercialization of academic resources have been encouraged (Etzkowitz 1983, 1998; Slaughter and Leslie 1997). Consequently, entrepreneurial activities in academia such as university startups, university patenting, technology transfer, and university-industry co-authorship have significantly increased (e.g., AUTM 2007; Nagaoka et al. 2009). However, there has been a criticism that this regime shift is contradictory to traditional scientific norms and hampers the progress of science (Dasgupta and David 1994; Nelson 2004). Under the traditional norms, the findings of academia have been regarded as the collective property of the scientific community and scientists are supposed to give up their property rights (Merton 1973). Despite these norms, many empirical studies have shown that scientists involved in commercial activities and UIRs tend to withhold their research results and resources from other scientists (e.g., Campbell et al. 2000; Walsh et al. 2007). Thus, the regime shift might have weakened the very basis of science even if entrepreneurship may directly contribute to society.

Despite a series of empirical evidence, much remains to be studied about how the entrepreneurial regime has affected the norm of open science. On the one hand, non-cooperative or secretive behaviors of scientists may be attributable to institutional deficiency in the entrepreneurial regime. Kenney and Patton (2009) and Marshall (2000) have shown several cases where university administrators hindered scientists from sharing their research resources in an attempt to exploit them as a budget source. Consequently, institutional restrictions could deter the willingness of scientists to serve to academia. On the other hand, as Dasgupta and David (1994) cautioned, the traditional norm for open science may have weakened and scientists have become more concerned about their own benefits. This scenario is much more serious than the previous one. If the norm is still sustained, it might be possible to address the conflict between entrepreneurship and open science by modifying the problematic part of the current system. However, if the norm has gone, such modifications might not resolve the conflict anymore.

Therefore, this study primarily aims to examine the transition of the normative structure of scientists under the entrepreneurial regime. Specifically, I focus on two dimensions of norms: the norm for open science, which has been long shared in the scientific community, and the norm for practical contribution to society, which has been emphasized under the new regime. This study analyzes whether the traditional norm has been weakened due to the emergence of the entrepreneurial regime and, more generally, whether the two normative dimensions are compatible or incompatible. In addition, this study examines how the norms affect the behaviors of individual scientists in terms of entrepreneurial activities and non-cooperative behaviors. To these ends, I conducted a survey of Japanese scientists in life science and material science. Since the regime shift toward entrepreneurship in Japan has occurred relatively recently (beginning the late 1990s), there is still some extent of flux and deviation in the organizational contexts. I expect this helps to reveal the association between the regime shift and the transition of the normative structure.

2 Conceptual background and hypothesis building

2.1 Normative structure in the contemporary academia

The last few centuries have witnessed a couple of major transitions in scientific norms. One important transition occurred at the beginning of the modern science in the nineteenth century, when open science became a dominant value replacing the previous ethos of secrecy (David 2004). In this open science regime, scientists believe that scientific progress depends on common heritage of past achievement. Thus, the findings in academia are the collective property of the scientific community, and open and full communication between scientists is essential (Merton 1973; Mitroff 1974). I define this norm as the *norm for open science* that academic scientists should openly and unconditionally contribute to scientific advancement and their peers. This norm has been maintained by mutual monitoring and sanctioning mechanisms inside the scientific community. For example, if a scientist does not follow the norm, such a deviant behavior is likely to be sanctioned, for example, by a denial of future cooperation. This norm has been practiced widely, if not perfectly,[1] and played an essential role in academia (Campbell et al. 2000; Hagstrom 1974; Walsh et al. 2007). Although it is regarded as a fundamental scientific norm, it can be influenced by social, economic, political, and historical factors (Blume 1974; Hackett 1990). For example, Laband and Tollison (2000) have indicated that the cooperativeness of scientists differ by scientific fields. Ellison (2002, 2007) have implied that the manner in which scientific discoveries are disseminated has been changing along with the social norms.

Another noteworthy norm shift occurred in the early twentieth century when academic science started to be proactively utilized for practical purposes (e.g., military purposes). From the perspective of policy makers, there has been an increasing understanding that academia should not be allowed to simply pursue fundamental knowledge without any direct benefit to society (Stokes 1997). This view is conceptualized as “accountability” that scientists should be accountable to and directed by their research sponsors, who are often the public (Hackett 1990). The scientific community has also come to consider practical contribution to society as an indispensable role of academic institutions and strengthen ties with industry (e.g., OECD 1999; National Academy of Sciences 1993). Moreover, Stokes (1997) has pointed out that practical orientation can even facilitate scientific progress. As an anecdote, he referred to Louis Pasteur, who achieved great progress in the field of basic microbiology while this success was largely based on his development of the fermentation technology to derive alcohol from beet juice. In this way, the *norm for practical contribution to society*, that academic scientists should directly contribute to solving problems in society, has formed an important aspect of scientific norms. Obviously, this norm has been more common in industrial research where private firms engage primarily in applied research (Goel and Rich 2005), but Kleinman and Vallas (2005) have argued that norms in academia and industry are converging across their boundary.

2.2 Entrepreneurial regime and the shift in norms

Although the orientation toward practical application is not quite new, the regime shift toward academic entrepreneurship since the 1980s has undoubtedly accelerated it in an

[1] Merton (1973) pointed out that the fierce scientific competition often discouraged cooperative relationships because scientists have to be the first to publish novel discoveries to gain recognition.

institutional manner (Etzkowitz 1998; Goel and Rich 2005; Slaughter and Leslie 1997). Among others, the Bayh-Dole Act in the US and similar laws in other countries played an indispensable role in the regime shift (Kenney and Patton 2009; Mowery and Sampat 2005). This was followed by various measures conducive to commercialism of university research (Powell and Owen-Smith 1998). Under the new regime, technology transfer to industry is emphasized, and university scientists are encouraged to exploit their private rights. By enhancing university patenting, the governments have expected that the expertise of academia and industry is complementarily utilized so that academic science contributes to society directly and effectively (Aghion and Tirole 1994; Nelson 2001; Poyago-Theotoky et al. 2002). To facilitate entrepreneurial activities of faculty members, universities have implemented mechanisms for entrepreneurship such as special organizations (e.g., technology licensing offices (TLOs), university-industry research centers) and intramural regulations (Glenna et al. 2007b; Poyago-Theotoky et al. 2002; Slaughter and Rhoades 1996). Subsequently, entrepreneurial activities in universities were boosted (Slaughter and Leslie 1997), which can be seen in various indicators such as the number of university startups, patent applications by universities, and technology transfer income (e.g., AUTM 2007; Arora et al. 2001; Brown et al. 1991; Henderson et al. 1998; Mowery et al. 2001; Nagaoka et al. 2009).

While the trend of entrepreneurship is clear from these outcome indicators, it has not been well examined how the regime shift has affected the scientific community with regard to the structure of scientific norms.[2] Previous theories have suggested that the norms and conducts of scientists can be influenced by science policies and institutions (Frickel and Moore 2005; Goel and Rich 2005). In the entrepreneurial regime, I assume that university-level interventions have affected scientists in two steps. First, university infrastructure was reformed to reduce the cost and increase the incentives for entrepreneurship. For example, TLOs provide patent attorneys who handle legal tasks, and also search for industry partners to whom university technologies are transferred. Venture business laboratories provide a venue for academia and industry to start collaborative enterprise. Such services cannot be easily obtained if scientists themselves have to find one. Further, university administrators give scientists incentives for entrepreneurial activities, for example, by allowing them to earn personal profit (e.g., licensing income, dividends from companies they are engaged in). These pecuniary incentives can drive scientists toward entrepreneurial activities. Once entrepreneurial activities begin to prevail and become less uncommon, an atmosphere to appreciate entrepreneurship can be spontaneously developed in the scientific community. Then, scientists who succeed in entrepreneurial activities can even earn esteem from their peers, which used to be given only to scientists who made scientific discoveries. This further encourages more scientists to be involved in entrepreneurial activities. In this self-reinforcing cycle, the norm for practical contribution is strengthened. To put differently, the normative structure would not change unless the cycle was accelerated. Etzkowitz (1990) has suggested that entrepreneurially active scientists were heavily disapproved of by their peers at the dawn of the regime shift. Stuart and Ding (2006) have also shown that the commercial propensity of scientists increases when there are commercially active scientists in their neighborhood. In this respect, university-level interventions may contribute to initiating the trend of entrepreneurship.

[2] In this paper, I use the concept of "norm" as the expected behaviors from the scientific community and distinguish it from actual behaviors. This distinction is based on the argument that the behaviors of a person is determined by his or her attitude toward a certain behaviors and the norms of significant others concerning the behaviors (Schuman and Johnson, 1976).

Although entrepreneurship has been widely accepted, the level of infrastructure for entrepreneurship varies with universities. For example, some universities have staffed greater number of employees for entrepreneurship, implemented larger special organizations, and accumulated more commercial experience than the others. Rich infrastructure for entrepreneurship can engender the atmosphere for entrepreneurship smoothly. Thus, it is straightforward to assume that scientists are more likely to follow the norm for practical contribution under stronger interventions for entrepreneurship by their university.

Hypothesis 1 Interventions for entrepreneurship at the university level are positively associated with the norm for practical contribution to society.

Compared to the norm for practical contribution, it can be controversial whether university interventions have deterred the norm for open science or not. Theoretically, the two norms are independent, so development in one norm does not necessarily mean weakening of the other. In fact, a few empirical studies have suggested that UIRs do not reduce the quality or quantity of scientific publications (Agrawal and Henderson 2002; Hall et al. 2003). Nevertheless, numerous studies have contended that the entrepreneurial regime is incompatible with the traditional academic norm (Dasgupta and David 1994; David 2003). As above mentioned, the entrepreneurial regime induces involvement in entrepreneurial activities of university scientists. This can simply cause multi-task substitution where entrepreneurially active scientists work less for traditional academic missions (Holmstrom and Milgrom 1991; Lee 1996). In addition, as widely recognized, entrepreneurial activities are often inconsistent with the academic practice of open science (e.g., Campbell et al. 2000; Walsh et al. 2007). For example, patent laws require the novelty of inventions, which is likely to delay publications. Industry partners in collaborative research tend to demand as exclusive a right of UIR output as possible. Moreover, some universities impose restrictions on free sharing of research resources even inside academia (Kenney and Patton 2009; Marshall 2000). As this tendency prevails, even if most scientists still believe the norm for open science, they will feel skeptical about the validity of the norm. They frequently encounter non-cooperative or secretive behaviors of entrepreneurial scientists and those under pro-property right restrictions. This makes it less reasonable for scientists to provide their resources in a gratis manner since it likely ends up in helping free-riders. Once such an understanding is formed, the traditional norm weakens and the mechanism of sanction does not fully function. In this way, there also is a self-reinforcing force to weaken the norm for open science. Therefore, scientists may less likely follow the norm for open science under greater interventions of their university to facilitate entrepreneurial activities.

Hypothesis 2 Interventions for entrepreneurship at the university level are negatively associated with the norm for open science.

2.3 Other determinants of the norm

In addition to the entrepreneurial environment, what can affect the scientific norms? At the organizational level, one noticeable difference between universities is the intensity of research activities. Some universities are capable of collecting greater amount of research funds than others. In addition, some universities attach greater importance to research compared to education than other universities do (Hackett 1990). Scientists in research-intensive universities can enjoy sophisticated research environment (e.g., experimental facilities, excellent co-workers) and concentrate more on research work. While these privileges are attained partly as a result of the efforts of scientists, the contribution of universities is not negligible. Thus, scientists feel obliged when they receive a great deal of support from their organization. One way to reciprocate this obligation is to feedback their research output to the scientific community. Universities with high research intensity tend to facilitate this process by offering human resources and infrastructure (e.g., repositories to share research tools and data, technicians to prepare research tools). Thus, I hypothesize that research intensity at the university level facilitates the norm for open science.

Hypothesis 3 Research intensity at the university level is positively associated with the norm for open science.

On the other hand, the effect of research intensity on the norm for practical contribution is controversial. If scientists are provided with excellent research environment, they are likely to produce greater amount of output than those in less privileged circumstances. This simply results in a higher probability of coming up with practically applicable discoveries. More importantly, research intensive universities are likely to attract industry partners. These conditions can facilitate the norm shift toward practical contribution. However, if we assume that contribution to society is a substitutive motivation for contribution to academia, the following explanation is also plausible. Namely, scientists in rich research environment can sufficiently contribute to academia with good amount of research output, so they do not have to pursue secondary mission to contribute to society. Scientists in poor research environment, to the contrary, may be more willing to contribute to society because their contribution to academia tends to be limited. In addition, Faria (2001) has argued that scientists tend to pursue external earnings (typified by consulting income) and not to concentrate on research when the standards of academic research is low. Thus, research-intensive universities, where a high level of scientific productivity is required, scientists may be discouraged from engaging in the secondary activities. To consider these competing possibilities, I formulate the following alternative hypotheses.

Hypothesis 4A Research intensity at the university level is positively associated with the norm for practical contribution to society.

Hypothesis 4B Research intensity at the university level is negatively associated with the norm for practical contribution to society.

In addition to the organizational contexts, scientific norms can differ by various contextual factors (Hackett 1990). Among others, scientific fields form the basic dimension of the scientific community, which is often called invisible college (Crane 1972). Because scientists in the same field share fundamental knowledge and research objectives, they are also likely to share values or standards on how they advance their science. As such, Goel and Rich (2005) have suggested that conducts of scientists differ by research characteristics and are influenced by academic societies. In addition, Brown et al. (1991) implies that behaviors of scientists are affected by technological characteristics such as complexity and uncertainty. For example, it is straightforward to assume that the norm for practical contribution is appreciated relatively strongly in applied science while the norm for open science is valued in basic science. With regard to open science, Vogeli et al. (2006) have shown different probabilities of withholding research data and materials between life science, computer science, and chemical engineering. Hong and Walsh (2009) have also suggested that the extent of secrecy is greater in biology than in mathematics and physics. More broadly, Laband and Tollison (2000) and Laband (2002) have examined how scientific discoveries are shared and credited in multiple fields. In addition, several studies have compared the selfishness or cooperativeness of scientists in economics and non-economics, although they have shown competing results (Carter and Irons 1991; Frank et al. 1993; Laband and Beil 1999; Marwell and Ames 1981). These studies imply that scientific norms are influenced by scientific fields.

Hypothesis 5A The norm for practical contribution to society differs by scientific fields.

Hypothesis 5B The norm for open science differs by scientific fields.

Finally, generation is another contextual dimension potentially dividing the scientific community (Hackett 1990). Since entrepreneurship is a rather new trend, older generation experienced it after experiencing the traditional regime. On the other hand, scientists in younger generation are under the influence of the new regime from the beginning of their career. Thus, I assume that younger generation has a stronger norm for practical contribution. In addition, assuming that the entrepreneurial regime negatively affected the norm for open science, I hypothesize that younger generation was more vulnerable.

Hypothesis 6A Scientists in younger generation have stronger norm for practical contribution to society.

Hypothesis 6B Scientists in younger generation have weaker norm for open science.

3 Data

3.1 Sample and data

For this study, I use a sample of scientists in Japanese universities. The Japanese academia has a couple of characteristics suitable for the objective of this study. First, the transition to entrepreneurial regime in Japan occurred relatively recently: for example, the Japanese-version of Bayh-Dole Act was enacted in 1999. Thus, I expect that there still remains heterogeneity in the stance toward entrepreneurship across universities. Second, the mobility of Japanese scientists is fairly low (Nagaoka et al. 2009),[3] so scientists are likely influenced by their current affiliation with limited influence from a previous affiliation.

I determined the population of this study with the following criteria. First, with regard to scientific fields, I primarily focused on life science, where academic entrepreneurship has been a major issue (National Academy of Sciences 2003). The field of life science is divided into 6 subfields (basic biology, basic medicine, clinical science, agricultural science, pharmaceutical science, medical engineering).[4] In addition, to move beyond prior work, I added material science, where industry collaboration plays an important role. Material science consists of material chemistry and nano science. Second, because this study is interested in scientists who were actually engaged in research activities, I selected full and associate professors in the top 45 universities who have received national funds in

[3] The scientists in my sample had been in their current laboratory for 13 years on average.

[4] The scientific field of each respondent was determined by a database of national research funds (explained later). The database records in what scientific fields each scientist has obtained research funds. I chose one field most frequently assigned for each scientist.

Table 1 Factor analysis with Varimax rotation for the scientific norms

Questionnaire items	Practical contribution	Open science
(1) More opinions from industry should be heard in order to make use of academic research for society	.76	.05
(2) Academic scientists should be more involved in useful research for society	.84	.00
(3) Academic scientists should indirectly contribute to society by pursuing intellectual curiosity. (reversed)	.56	−.27
(4) Academic scientists should cooperate even with competitors in order to advance science	.07	.81
(5) Even research results unfavorable for authors should be completely published without delay	−.06	.78
(6) Even if no benefit is expected, requests for cooperation from other academic scientists should be fulfilled	−.19	.55

the last 5 years. Since no up-to-date sampling frame satisfying the criteria was available, I created an original sampling frame using a database of Japanese national research funds.[5]

The survey was conducted as follows. First, I interviewed 30 academic scientists, based on which I constructed survey instruments. To validate the instruments, I conducted a preliminary survey of 40 scientists randomly selected from the sampling frame. Then, I had cognitive interviews with ten scientists to correct any unclear or inappropriate questions. The revised survey was mailed to 1,674 randomly sampled scientists in February through April of 2009. I collected 698 responses with a response rate of 42%.[6] The respondents consist of 83% of life scientists and 17% of material scientists. On average, they obtained their highest degree (Ph.D. or MD) in 1988, had worked in 2.8 laboratories in their career, and had been in their current laboratory for 13 years. The mean laboratory size was six researchers. The mean number of publications was 6 per year.

In addition to the survey, I drew on a national survey data on UIRs for the measures of university-level interventions for entrepreneurship.[7] The survey basically covered all Japanese universities and included responses from all the 45 universities in the sample of this study.

3.2 Measures

3.2.1 Scientific norm

Since limited measures for scientific norms were available, I designed survey items primarily on the basis of the interviews. I partly drew on the measures developed by Glenna et al.

[5] I drew on the database of Grant-in-Aid for Scientific Research, which is a competitive research fund and is the primary funding source for Japanese university scientists. My sampling frame includes 8,013 scientists, covering 62% of all the grantees who satisfy my population criteria.

[6] I tested for non-response bias as follows. I obtained publication data from the Web of Science for 100 scientists in each of the response and non-response groups, and checked for differences in publication productivity across the two groups. We find no significant difference (7.4 vs. 9.1 publications per year, $p = 0.22$). However, I found that full professors were less responsive than associate professors (38 vs. 46%, $p < 0.01$). Therefore, my sample represents the population in terms of productivity but may have over-sampled younger scientists.

[7] The detail of the national survey is explained in Shibayama and Saka (2010) and on the government's website (http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm).

(2007a) as for the norm for practical contribution. By definition, norms are *shared* values, standards, and so forth in a particular community, so it is straightforward to use community-level measurement. However, this "community" can be defined from various angles such as scientific fields and geographical areas (Hackett 1990). In addition, one scientist may be embedded in multiple communities (e.g., multiple scientific fields for multidisciplinary scientists). To address this multiplicity, this study uses individual-level measurement for what individual scientists believed the norms in their community are like. I prepared three items for each of the two dimensions of norms (Table 1). They inquired to what extent the respondents believed each item agrees with the norms in their community (five-point scale; 1: disagree—5: agree). As shown in the next chapter, a factor analysis yielded two factors corresponding to the intended norms, so these factors are used as the measures of the two norms (*norm for practical contribution* and *norm for open contribution*).

3.2.2 Entrepreneurial intervention

I prepared several measures for entrepreneurial interventions at the university level. First, I counted the number of special organizations for entrepreneurship in each university (*#special organizations*), where special organizations included an affiliated TLO, an intellectual property management office (IPMO), a co-research center, a business incubation office, and a liaison office. Second, I used the age of the special organizations. Older organizations imply a longer history and more earnest efforts for entrepreneurship. Specifically, I focused on TLO and IPMO for their basic role in university entrepreneurship (*age of TLO* and *age of IPMO*).[8] Third, I counted the number of intramural regulations and guidelines regarding entrepreneurship (*#regulations*).[9] Fourth, in order to gauge the overall influence of organizational support for entrepreneurship, I prepared a survey measure (*support for entrepreneurship*): "the support for industry collaboration is sufficient in my university" (1: disagree—5: agree). In addition, I proxied the effectiveness of the above interventions by past entrepreneurial achievements. Namely, I counted the number of patent applications per scientist in the previous year (in 2006) (*#patent per scientist*) and took its logarithm.

3.2.3 Research intensity

I calculated the amount of research budget per scientist in each university in the previous year (*¥research budget per scientist*), and took its logarithm.

3.2.4 Scientific fields

I included seven dummy variables for the eight fields.

3.2.5 Generation

I distinguished three generation groups. The first is those who obtained their degree after 1996, which represents a relatively young generation whose research career began after the

[8] In Japan, TLOs used to be an external organization for legal reasons (some have later became part of universities). A single TLO may be affiliated with multiple universities. IPMOs, on the other hand, are an intramural organization.

[9] The national survey asked whether each university had the regulations or guidelines regarding licensing, material transfer, UIRs, conflict of interest, intellectual property, co-research, and employee invention.

regime shift (*young generation*). The second is those who obtained their degree before 1983, a relatively old generation whose research career will end in less than 10 years (*old generation*). The third is between the two generations (*middle generation*), which is used as a base group in regressions.

3.2.6 Entrepreneurial activity and non-compliance with academic practice

To examine the relation between norms and actual behaviors of individual scientists (partly for the validation of the norm measures), I prepared four measures for entrepreneurial activities and two measures for non-compliance with academic practice. First, following Campbell et al. (2002), if a scientist is involved in at least one type of commercial activity in 2007–2008, a dummy variable is coded one (*involved in commercial activity*), where commercial activity includes negotiation with industry, planning of a new business, foundation of start-ups, development and marketing of new technologies, and earning license income. Second, following Campbell et al. (2000), if a respondent had applied for at least one patent during the last 2 years, a dummy variable is coded one (*patented at least once*). Third, following Hong and Walsh (2009), if a respondent had at least one industrial collaborator, a dummy variable is coded one (*collaborating with industry*). Fourth, following Hong and Walsh (2009) and Campbell, et al. (2002), if a respondent had received research funds from industry, a dummy variable is coded one (*funding from industry*).[10] As for academic practice, I first drew on non-compliance with open communication in publications. Although publication is the basic mechanism to share research results, scientists sometimes exclude part of their results from publications to keep scientific leads or protect commercial values (Blumenthal et al. 1997, 2006). Following Blumenthal et al. (2006), if a scientist had intentionally excluded information from publication in the last 2 years, a dummy variable is coded one (*secretive publication*). Second, I drew on material transfer or the sharing of research tools (e.g., reagents, cell lines, chemical compounds, and model organisms). Natural scientists frequently share research tools to avoid redundant work and accelerate research, but requests for sharing are sometimes declined for various reasons (Campbell et al. 2000; Walsh et al. 2007). Following, Walsh et al. (2007), I asked whether the respondents fulfilled or denied the request for material transfer they received most recently. If they denied it, a dummy variable is coded one (*denial of material transfer*).

3.2.7 Control variables

I controlled the performance of scientists by the logarithm of the number of publications in the last 2 years (*#publication*). I also controlled the amount of yearly research budget that the respondents individually obtained (*¥individual research budget*: seven-point scale from ‘less than 5 million yen’ to ‘more than 100 million yen’). To control organizational rank, a dummy variable is coded one for a full professor and zero for an associate professor (*full professor*). Finally, I controlled whether a university is private or public since the ownership structure may affect the management of the university (*private school*).

[10] In this study, *funding from industry* is used as a measure of entrepreneurial activity but not as a measure of entrepreneurial intervention. In Japanese universities, very few laboratories originated from industry funding, so the funding source is regarded as a matter of choice but not a given condition.

4 Results

4.1 Normative structure

To examine the structure of scientific norms, I ran factor analyses for the six questionnaire items. An exploratory factor analysis resulted in a two-factor solution based on the Kaiser-Guttman criterion (i.e., eigenvalues greater than one) and a scree test (Table 1). The two factors correspond to the intended normative dimensions, where all factor loadings are above 0.55 and cross-loadings are below 0.27. Further, a confirmatory factor analysis in which each item was constrained to load just on the intended factor indicated a reasonable fit to the data: goodness-of-fit index (GFI) = 0.98, comparative fit index (CFI) = 0.93, and root-mean-square error of approximation (RMSEA) = 0.08. These results suggest that the survey measures account for the two dimensions of norms.

4.2 Determinants of norms

Table 2 shows the results of regressions predicting the two norms. Table 2(A) predicts the norm for practical contribution to society while Table 2(B) predicts the norm for open science. In each table, I tested six models drawing on the different measures of entrepreneurial interventions. In these regressions, the random effects of universities are considered, where Hausman tests indicate no endogeneity due to random errors. Appendix Table 5 shows the description and correlations of the variables.

To support Hypothesis 1, Models 1, 3, 5, and 6 indicate significantly positive coefficients of entrepreneurial interventions. Special organizations tend to strengthen the norm for practical contribution (*#special organization*: $b = 0.35$, $p < 0.05$ (Model 1); *age of IPMO*: $b = 0.06$, $p < 0.05$ (Model 3)), although the *age of TLO* does not show a significant effect (Model 2). Model 4 indicates that intramural regulations are not significantly effective. The subjective measure of *support for entrepreneurship* indicates a significantly positive coefficient (Model 5: $b = 0.13$, $p < 0.001$), and the past entrepreneurial achievement is also positively associated with the norm for practical contribution (Model 6: $b = 0.08$, $p < 0.05$). On the other hand, Models 7–12 do not indicate any significant effects of entrepreneurial interventions on the norm for open science. Most coefficients even indicate positive signs. Thus, Hypothesis 2 is rejected.

Next, research intensity shows significantly positive effects on the norm for open science (Models 7 and 9–12), which is supportive to Hypothesis 3. On the norm for practical contribution, research intensity shows significantly negative effects (Models 1–6). Thus, Hypothesis 4A is rejected and Hypothesis 4B is supported.

The dummy variables for scientific fields are jointly significant ($p < 0.001$) in all models for both norms, supporting Hypotheses 5A and 5B. Figure 1 illustrates the average levels of the two norms in eight fields. The figure indicates that clinical science has a relatively strong norm for practical contribution, whereas basic biology shows a fairly weak norm for practical contribution. In addition, nano science has a relatively strong norm for open science, while material chemistry is weak in this norm. Interestingly, pharmaceutical science has rather strong norms in the two dimensions.

As for generation difference, *young generation* (whose career began after the regime shift) shows a strong norm for practical contribution (Models 1–6). This supports Hypothesis 6A, indicating that the regime shift facilitated the norm for practical contribution. On the other hand, *young generation* does not show a significant difference in the norm for open science (Models 7–12), which rejects Hypothesis 6B. Thus, the regime shift

Table 2 Regressions predicting norms

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(A) Norm for practical contribution to society						
Control						
ln (# Publications)	.23*** (.07)	.23*** (.07)	.22** (.07)	.23*** (.07)	.24*** (.07)	.23*** (.07)
¥ Individual research budget	−.04 (.03)	−.04 (.03)	−.04 (.03)	−.04 (.03)	−.05† (.03)	−.04 (.03)
Full professor	.04 (.10)	.05 (.10)	.05 (.10)	.04 (.10)	.06 (.09)	.05 (.10)
Private school	.43*** (.07)	.32** (.11)	.38*** (.07)	.37*** (.10)	.29** (.11)	.35*** (.11)
Generation [H6A]						
Young generation	.24* (.10)	.23* (.10)	.23* (.10)	.23* (.10)	.24* (.10)	.22* (.10)
Middle generation (base group)						
Old generation	.14 (.10)	.13 (.10)	.14 (.10)	.14 (.10)	.12 (.10)	.12 (.10)
Scientific field [H5A]						
Field dummies (joint test)	SIG ***	SIG ***	SIG ***	SIG ***	SIG ***	SIG ***
Research intensity [H4AB]						
ln (¥ Research budget per scientist)	−.40*** (.11)	−.43** (.14)	−.39*** (.11)	−.37** (.14)	−.34** (.12)	−.43** (.13)
Entrepreneurial intervention [H1]						
# Special organizations	.35* (.15)					
Age of TLO		.01 (.01)				
Age of IPMO			.06* (.03)			
# Regulations				.23 (.24)		
Support for entrepreneurship					.13*** (.04)	
ln (# Patent per scientist)						.08* (.04)
χ^2 test	232.49 ***	103.67 ***	209.34 ***	115.43 ***	201.08 ***	99.26 ***
Overall R^2	.14	.14	.14	.14	.15	.14
N	666	666	666	666	666	666

Table 2 continued

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
(B) Norm for open science						
Control						
ln (# Publications)	.01 (.07)	.01 (.07)	.01 (.07)	.01 (.07)	.01 (.07)	.01 (.07)
¥ Individual research budget	.01 (.05)	.01 (.05)	.01 (.05)	.01 (.05)	.01 (.05)	.01 (.05)
Full professor	−.20* (.08)	−.19* (.08)	−.20* (.08)	−.20* (.08)	−.20* (.08)	−.20* (.08)
Private school	.05 (.12)	.03 (.11)	.04 (.12)	.00 (.13)	.01 (.12)	−.02 (.13)
Generation [H6B]						
Young generation	−.12 (.10)	−.12 (.10)	−.12 (.11)	−.12 (.11)	−.12 (.10)	−.12 (.11)
Middle generation (base group)						
Old generation	$-.14^{\dagger}$ (.08)	$-.15^{\dagger}$ (.08)	$-.14^{\dagger}$ (.08)	$-.14^{\dagger}$ (.08)	$-.15^{\dagger}$ (.08)	−.13 (.08)
Scientific field [H5B]						
Field dummies (joint test)	SIG ***	SIG ***	SIG ***	SIG ***	SIG ***	SIG ***
Research intensity [H3]						
ln (¥ Research budget per scientist)	$.22^{\dagger}$ (.13)	.13 (.17)	$.22^{\dagger}$ (.12)	$.25^{\dagger}$ (.13)	.24* (.12)	.29* (.14)
Entrepreneurial intervention [H2]						
# Special organizations	.11 (.18)					
Age of TLO		.02 (.02)				
Age of IPMO			.03 (.03)			
# Regulations				−.02 (.26)		
Support for entrepreneurship					.02 (.04)	
ln (# Patent per scientist)						−.04 (.04)
χ^2 test	156.01 ***	145.34 ***	146.91 ***	152.87 ***	153.54 ***	150.99 ***

Table 2 continued

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Overall R^2	.06	.06	.06	.06	.06	.06
N	666	666	666	666	666	666

GLS regression with random-effects of universities. Unstandardized coefficients and robust standard errors (parentheses)

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-tailed test)

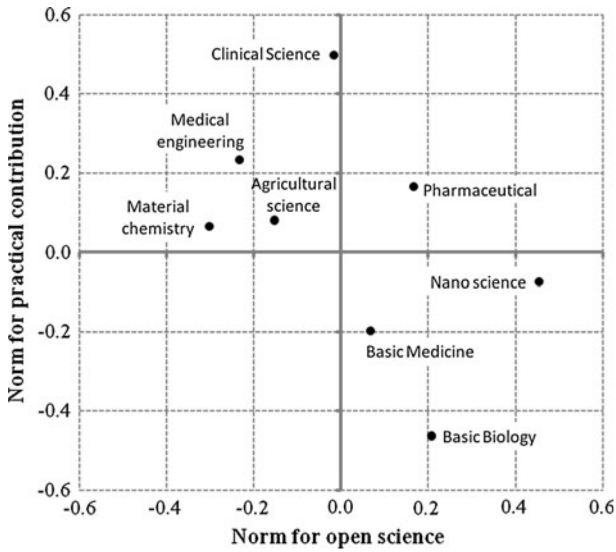

Fig. 1 Norms in different fields. The scales for horizontal and vertical axes are the number of standard deviations from the mean for the whole sample

may not have necessarily deteriorated the norm for open science. However, the coefficients are still negative, which might indicate the symptom of the decline in the norm for open science. Models 7–12 also show negative coefficients for *old generation* and *full professor*. These results suggest that scientists who have already attained a certain status may lose their motivation to unconditionally contribute to the scientific community. Table 3 summarizes the results of all hypothesis tests.

In addition, Models 1–6 show strongly positive coefficients for private school. In Japan, the majority of research-intensive universities are public, but several private universities have attained prestigious positions as research universities (In my sample, 10 of 45 universities are private). Possibly because of their private ownership, the entrepreneurial regime might have been easily adopted compared to public universities. Performance is also positively associated with the norm for practical contribution (Models 1–6). This may be because high performers tend to have more opportunities for entrepreneurship.

4.3 Normative shift, entrepreneurial activity, and non-compliance

In order to examine the relation between the norms and actual behaviors of scientists, I further tested several models predicting entrepreneurial activities (Table 4(A)) and non-compliance with academic practice (Table 4(B)) by the two norms. Models 1–4 show that the norm for practical contribution increases the likelihood of involvement in commercial activity (Model 1: $b = 0.43$, $p < 0.001$), patenting (Model 2: $b = 0.32$, $p < 0.001$), industry collaboration (Model 3: $b = 0.43$, $p < 0.001$), and funding from industry (Model 3: $b = 0.34$, $p < 0.001$). On the other hand, the norm for open science shows a significant effect only on patenting ($b = -0.17$, $p < 0.1$).

Models 5 and 6 predict whether a scientist had concealed some information from publication. Both models show that the norm for open science suppresses secretive publication, or promote open publication ($b = -0.34$, $p < 0.05$; $b = -0.33$, $p < 0.05$,

Table 3 Summary of the results

	Norm for practical contribution			Norm for open science		
	Hypothesis		Result	Hypothesis		Result
Entrepreneurial intervention	***H1***	+	+	H2	−	N.S.
Research intensity	H4A ***H4B***	+ −	−	***H3***	+	+
Scientific field	***H5A***	Differ by field	E.g., high in clinical sci. and med. eng.	***H5B***	Differ by field	E.g., high in nano sci. and basic biol.
Generation	***H6A***	Strong in young generation	Young > Middle	H6B	Weak in young generation	Middle > Old

Bold italic are accepted hypotheses

respectively). Model 5 also indicates that the norm for practical contribution facilitates secretive publication ($b = 0.51$, $p < 0.01$). This effect decreases when entrepreneurial activities are included in Model 6 ($b = 0.34$, $p < 0.05$). Model 6 indicates involvement in commercial activity and patenting facilitate secretive publication ($b = 0.88$, $p < 0.01$; $b = 0.88$, $p < 0.05$, respectively), which implies a mediating effect of entrepreneurial activities. Models 7 and 8 predict the likelihood of denying material transfer. Both models indicate that the norm for open science suppresses this non-compliant behavior ($b = -0.39$, $p < 0.05$; $b = -0.47$, $p < 0.05$), but the norm for practical contribution does not affect this behavior. Model 8 shows that involvement in commercial activity significantly deters material transfer ($b = 2.11$, $p < 0.05$). Models 6 and 8 do not show significant effects of collaboration with industry and funding from industry, suggesting that not all types of entrepreneurial activities induce non-compliant behaviors.

5 Discussion

In the trend of academic entrepreneurship, the practical and direct contribution of university research to the society has been emphasized, in which scientists have been encouraged to engage in commercial activities and UIRs (Etzkowitz 1983, 1998; Slaughter and Leslie 1997). However, this movement has aroused concern about its potentially negative impact on the tradition of open science (Dasgupta and David 1994; Nelson 2004). This study, disentangling the behaviors and norms of individual scientists, attempts to examine the compatibility between entrepreneurship and open science.

First, this study focuses specifically on the norms for practical contribution to society and for open science, and examines the impact of entrepreneurial infrastructure of universities on the norms. Overall, the results suggest that entrepreneurial infrastructure tends to facilitate the norm for practical contribution. Especially, special organizations for entrepreneurship (e.g., IPMO) are influential. In addition, university-level past experience in entrepreneurial activities measured by patent applications is found to promote the norm. However, intramural regulations for entrepreneurship do not show a significant effect, possibly because the enforcement of university regulations is usually fairly weak in Japan. As for the norm for open science, on the other hand, the results do not indicate significant evidence that the norm is deterred by entrepreneurial infrastructure.

Table 4 Regressions predicting behaviors of scientists by norms[a]

	Involved in commercial activity Model 1	Patented at least once Model 2	Collaborating with industry Model 3	Funding from industry Model 4
(A) Entrepreneurial activities				
Control				
ln (# Publications)	.47*** (.16)	.44 ** (.17)	.20 (.15)	.62 *** (.16)
¥ Individual research budget	.30*** (.07)	.41 *** (.08)	.25 *** (.07)	.24 ** (.07)
Full professor	.14 (.23)	−.20 (.24)	−.26 (.24)	.44† (.23)
Private school	.18 (.28)	.77 ** (.30)	.10 (.29)	.01 (.28)
Young generation	.04 (.26)	−.18 (.26)	−.04 (.26)	.48† (.28)
Middle generation (base group)				
Old generation	−.20 (.23)	.20 (.24)	.00 (.25)	−.28 (.23)
Field dummies (joint test)	SIG *	SIG ***	SIG **	SIG ***
Scientific norm				
Norm for practical contribution	.43 *** (.10)	.32 *** (.10)	.43 *** (.10)	.34 *** (.10)
Norm for open science	−.04 (.10)	−.17† (.09)	−.07 (.10)	.03 (.09)
χ^2 test	79.29 ***	105.92 ***	59.95 ***	115.28 ***
Pseudo R^2	.12	.17	.09	.17
N	666	661	666	649

	Secretive publication		Denial of material transfer	
	Model 5	Model 6	Model 7	Model 8
(B) Non-compliance with academic practice				
Control				
ln (# Publications)	.36 (.23)	.15 (.25)	.42 (.32)	.56† (.33)
¥ Individual research budget	.16† (.09)	.03 (.10)	−.49* (.20)	−.57** (.20)
Full professor	−.46 (.41)	−.43 (.42)	.87* (.43)	.90† (.48)
Private school	.81* (.39)	.68 (.44)	−.32 (.79)	−.01 (.88)
Young generation	−.09 (.38)	−.08 (.41)	.48 (.51)	.54 (.56)
Middle generation (base group)				
Old generation	.32 (.39)	.29 (.40)	−.27 (.51)	−.49 (.53)
Field dummies (joint test)	SIG*	NS	NS	NS
ln (# Materials requested)[b]			−1.05*** (.31)	−1.07***(.31)
Scientific norm				
Norm for practical contribution	.51** (.17)	.34* (.16)	.14 (.22)	.16 (.26)
Norm for open science	−.34* (.14)	−.33* (.14)	−.39* (.19)	−.47* (.22)
Entrepreneurial activity				
Involved in commercial activity		.88** (.32)		
Requested material was commercialized[c]				2.11* (.85)
Patented at least once		.88* (.35)		
Requested material was patented[c]				.79 (.56)
Collaborating with industry		−.15 (.29)		−1.12 (.72)
Funding from industry		.29 (.31)		.21 (.55)
χ^2 test	49.60 ***	73.86 ***	36.26 **	49.05 ***

Table 4 continued

	Secretive publication		Denial of material transfer	
	Model 5	Model 6	Model 7	Model 8
Pseudo R^2	.12	.17	.15	.20
N	641	641	385[d]	385[d]

[a] Logit regressions. Unstandardized coefficients and robust standard errors (parentheses).† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-tailed test)

[b] The total number of requests for material transfer is controlled

[c] For model 8, I prepared variables for entrepreneurship specifically concerning the latest request for material transfer

[d] Respondents who had received no material request are excluded

Next, this study examines the association between the norms and behaviors of scientists. The results show that the norm for open science suppresses secretive and non-cooperative behaviors while the norm for practical contribution facilitates participation in entrepreneurial activities such as commercial involvement, patenting, and UIRs. Coupling with the effects of entrepreneurial infrastructure, this result suggests that entrepreneurial regime facilitates entrepreneurial activities at the individual level, which is consistent with many empirical studies (e.g., AUTM, 2007). This study also implies that the norm for practical contribution can induce secretive or non-cooperative behaviors, mediated by the involvement in entrepreneurial activities. This also agrees with previous literature alarming the negative impact of entrepreneurship (e.g., Campbell et al. 2000; Walsh et al. 2007). However, the results also imply that the norm for practical contribution and entrepreneurial activities do not necessarily lead to secretive or non-cooperative behaviors.

In addition to the university infrastructure for entrepreneurship, this study examines other determinants of the two scientific norms. Although Hackett (1990) has suggested that norms can change with organizational contexts, scientific fields, and generation, limited studies have empirically tested this argument. First, research intensity is examined as a noticeable contextual factor, and the results indicate that it facilitates the norm for open science and suppresses the norm for practical contribution. Second, the results show the two norms significantly differ by scientific field. Third, the results suggest that younger generation, who experienced the regime shift in their early career, tends to strongly follow the norm for practical contribution. However, the norm for open science is not found significantly weak for young generation. This implies that the regime shift in Japan might not have compromised the traditional norm for open science, although we have to cautious about this interpretation since the effects of the age and cohort cannot be well disentangled in the cross-sectional data. As a whole, the results suggest that the two norms are determined by independent mechanisms, where an increase in one norm does not necessarily mean a decrease in the other. This is encouraging news in that entrepreneurship can be promoted without damaging the norm which underpins open science. This is supportive to a line of studies implying consistency between entrepreneurship and traditional scientific activities (Agrawal and Henderson 2002; Hall et al. 2003).

These results offer the following policy implications. Despite all the criticism on entrepreneurship, this study suggests potential compatibility between academic entrepreneurship and the tradition of open science at least at the norm level. In order to fully achieve it, we have to mitigate the effects of entrepreneurship inducing non-cooperative or secretive behaviors. One potential solution for this is to strengthen the norm for open science. Based on the results, enrichment in research intensity can promote the norm for open science. As the results indicate, the increase of research budget is one approach, but other approaches may contribute to greater research intensity. For example, universities can enhance common experimental facilities, employ more technical or administrative staff, and establish infrastructure for inter-university cooperation (e.g., repository of research tools). Universities may also allow greater research time and give higher autonomy for faculty members. In this way, universities may improve the perceived level of research intensity for individual scientists. Another solution to suppress the adverse effects of entrepreneurship is to discourage entrepreneurial activities which are not expected to result in a meaningful outcome. For example, when a certain scientific resource is mainly used by university scientists, patenting such a resource should be discouraged. Otherwise, it only causes secrecy in publication with limited practical contribution. The initiatives of Public Intellectual Property Rights for Agriculture (PIPRA) and Biological Innovation for Open Society (BiOS) have attempted to foster open science through this approach (Lei et al. 2009). Involvement in commercial activities can also contradict open science, so non-promising commercialization should be avoided. Especially, considering that university startups are rarely successful, university scientists should ponder whether they have to engage in commercial activities to such a deep level. They may well rely on industry partners in an advanced stage of commercialization. The optimal forms of academic entrepreneurship may have to be reconsidered. For example, the results indicate that industry collaboration and industry funding do not deter open science.

The findings of this study should be considered with the following limitations. First, my sample selection restricts the generalization of the results. Especially, the national background is likely to affect the normative structure. Future research needs to replicate this study in different contexts for greater external validity. Second, we have to be cautious about the possibility of endogeneity due to the nature of cross-sectional data. Because the regime shift toward academic entrepreneurship occurred relatively recently in Japan, it is interesting to re-examine the situation in a few years using a panel data. Third, the measures of norms using subjective survey instrument can be biased although their significant associations with behavioral measures lend reasonable validity.

Acknowledgments I acknowledge Prof. John P. Walsh at Georgia Institute of Technology and Prof. Yasunori Baba at the University of Tokyo for their invaluable support for this project. I appreciate an anonymous reviewer for critical comments. I also appreciate Prof. Cristiano Antonelli at the University of Turin for reviewing an earlier version of this paper presented at BRICK-DIME-STRIKE workshop, the Organization Economics and Policy of Scientific Research, in 2010. I wish to express my gratitude to all the interviewees and respondents of the survey. I acknowledge Ms. Ayaka Saka and Mr. Terutaka Kuwahara at National Institute of Science and Technology Policy for providing the national survey data, and Prof. Hideaki Takeda at the National Institute of Informatics for providing the national grant database. I thank Ms. Asako Chiba for technical support. This study is supported by Postdoctoral Fellowships for Research Abroad of the Japan Society for the Promotion of Science. The views expressed herein are those of the author and do not necessarily reflect the views of National Institute of Science and Technology Policy.

Appendix

See Table 5.

Table 5 Description and correlation matrix

Variable	Mean	SD	Min	Max	1	2	3	4	5	6	7	8
Scientific norm												
Norm for practical contribution	.00	1.00	−2.16	2.97								
Norm for open science	.00	1.00	−3.80	2.25	.00							
Entrepreneurial intervention												
# Special organizations	.84	.24	.00	1.00	−.04	.04						
Age of TLO	6.35	3.64	.00	11.00	−.07	***.09***	***.59***					
Age of IPMO	4.36	1.17	.00	5.00	−.03	.05	***.69***	***.48***				
# Regulations	.75	.19	.00	1.00	−.07	.03	***.62***	***.47***	***.52***			
Support for entrepreneurship	2.88	1.08	1.00	5.00	***.16***	.02	***.09***	***.09***	.06	.02		
ln (# patent per scientist)	−2.47	.78	−5.30	−1.32	−.06	.01	***.51***	***.58***	***.53***	***.52***	.07	
Other contextual factor												
ln(¥ research budget per scientist)	−3.89	.30	−4.83	−3.40	***−.14***	.07	***.36***	***.66***	***.33***	***.39***	.04	***.55***
Young generation	.18	.38	.00	1.00	.06	.01	−.02	.00	.00	−.03	−.02	.06
Old generation	.29	.46	.00	1.00	.06	***−.10***	.01	.05	.00	−.02	.07	***.09***
Entrepreneurial activity												
Involved in commercial activity	.32	.47	.00	1.00	***.20***	−.03	−.02	−.04	***−.07***	−.03	***.10***	−.03
Patented at least once	.40	.49	.00	1.00	***.17***	***−.11***	−.03	.00	−.03	−.07	***.16***	.06
Collaborating with industry	.28	.45	.00	1.00	***.18***	−.05	−.03	−.01	−.03	−.07	***.08***	.00
Funding from industry	.51	.50	.00	1.00	***.22***	−.03	.02	−.05	−.04	−.05	.06	−.01
Non-compliance with academic practice												
Secretive publication	.11	.31	.00	1.00	***.12***	***−.15***	−.07	.01	.00	−.02	.02	.01
Denial of material transfer	.08	.28	.00	1.00	−.06	***13***	.08	***.19***	.07	***.10***	−.04	***.15***
Control variable												
ln (# publications)	2.27	.71	.00	4.62	***.14***	−.04	***.10***	***.15***	***.11***	.06	.03	***.13***
¥ individual research budget	2.70	1.44	1.00	7.00	.00	.01	.06	***.24***	***.07***	.04	***.10***	***.23***
Full professor	.52	.50	.00	1.00	.04	***−.11***	.01	−.01	−.02	.00	.02	−.01
Private school	.11	.32	.00	1.00	***.13***	−.02	***−.55***	***−.30***	***−.40***	***−.55***	.03	***−.38***

Table 5 continued

Variable	9	10	11	12	13	14	15	16	17	18	19	20
Scientific norm												
Norm for practical contribution												
Norm for open science												
Entrepreneurial intervention												
# Special organizations												
Age of TLO												
Age of IPMO												
# Regulations												
Support for entrepreneurship												
ln (# patent per scientist)												
Other contextual factor												
ln (¥ research budget per scientist)												
Young generation	.04											
Old generation	−.01	***−.30***										
Entrepreneurial activity												
Involved in commercial activity	−.03	.03	.04									
Patented at least once	.01	.03	***.10***	***.46***								
Collaborating with industry	−.02	.05	.01	***.30***	***.25***							
Funding from industry	−.05	.10	.01	***.34***	***.29***	***.35***						
Non-compliance with academic practice												
Secretive publication	.01	.02	.07	***.22***	***.26***	***.12***	***.15***					
Denial of material transfer	***.14***	−.04	.00	−.02	−.03	.05	.04	.06				
Control variable												
ln (# publications)	***.14***	−.01	***.15***	***.24***	***.27***	***.17***	***.31***	***.14***	.00			
¥ individual research budget	***.30***	.01	***.16***	***.23***	***.28***	***.17***	***.23***	***.10***	***.12***	***.45***		
Full professor	−.04	***−.41***	***.49***	***.08***	.06	.01	***.10***	.01	−.06	***.24***	***.25***	
Private school	***−.27***	−.02	.04	.03	***.08***	.02	.02	.07	−.05	−.07	−.03	.05

$N = 698$. Bold italic: $p < 0.05$

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