

Field Characteristics Differentiates the Mechanism of Scientist Cooperation - Material Transfer in Life Science and Material Science -

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Abstract

Using a sample of Japanese academic scientists, this study examines behavioral patterns of scientists especially in material transfer transactions. The results indicate that some characteristics of scientific fields differentiate scientists' behavioral patterns. First, in some fields scientists tend to demand some forms of return when supplying research materials. They are less likely to provide their materials when their benefits are not clear. This reciprocal behavior, along with market-oriented one, can impede a proper flow of research materials. Second, when the reciprocal behaviors become dominant at the field level, it can aggravate the withholding behaviors of commercially-active scientists. On the other hand, when commercial activities prevail at the field level, the reciprocal behaviors are accelerated. Thus, the trend of commercialization and the reciprocal climate can reinforce each other and lead to further anti-communal consequences. As a potential solution to this, restriction on commercial income can alleviate withholding behaviors of commercially-active scientists. Third, scientists tend to fulfill material requests from previous collaborators and colleagues. This tendency is particularly strengthened when network density is high, and the flow of research materials is restricted inside small networks. These results imply that we should consider more about field characteristics to design suitable policy interventions to facilitate scientist cooperation.

1. Introduction

Cooperation between academic scientists is an essential element of the advancement of science (Beaver & Rosen, 1978; Bozeman & Corley, 2004). Many forms of cooperation are used in the academia; such as co-research, co-use of experimental devices, and data sharing. Among others, material transfer is a particularly unique and important form of cooperation in natural science (National Academy of Sciences, 2003). Natural scientists develop various research materials as tools or products of their research; such as reagents, cell lines, plasmids, chemical compounds, and model organisms. As these materials take expertise, time and cost to prepare, they are frequently shared between academic scientists to avoid redundant work and to accelerate research (Walsh, Cohen, & Cho, 2007). For example, agricultural scientists in the US universities receive two research tools every year (Lei, Juneja, & Wright, 2009), and biomedical scientists in the US academic research organizations made 3.5 requests for material transfer every year (Walsh et al., 2007). Thus, material transfer functions as an indispensable system which enables academic scientists to advance their research based on prior knowledge crystallized in materials.

This crucial system has been underpinned by a set of scientific norms in which research output produced by academic scientists is regarded as a property of the academia (Merton, 1973). However, we have seen a transition in the norms and consequently in the mechanism of material transfer. For example, scientists and academic organizations claim their proprietary rights of their research materials (Lei et al., 2009). Scientists involved in commercial activities tend to withhold their research materials to protect their commercial values (Vogeli et al., 2006; Walsh et al., 2007). Consequently, we have seen decline in compliance with requests for material transfer (e.g., Blumenthal, Campbell, Anderson,

Causino, & Louis, 1997; Walsh et al., 2007). Walsh et al. (2007) shows that failure to receive research materials can result in significant delay of research projects, and that one in nine projects is abandoned every year by every scientist.

In order to alleviate the problems of withholding and secretive behaviors in the academia, funding agencies and science communities have implemented some countermeasures. For example, the US National Institute of Health (NIH) evaluates grant applications with plans for data sharing. Public Intellectual Property Rights for Agriculture (PIPRA) initiatives have recommended not to patent research tools used mainly by academic scientists. The effects of these efforts are still open to argument (e.g., Lei et al., 2009). Science policy scholars have studied impeding factors in material transfer, such as commercial involvement and industry relationship (Blumenthal et al., 1997; Walsh et al., 2007). They have primarily examined attributes of individual scientists and focused on specific fields in life science. However, because behaviors and values of scientists can differ with environment such as scientific fields (Hackett, 1990), previous findings may not necessarily apply in general. In this respect, we still have much to examine about background mechanisms affecting behaviors of scientists. Specifically, this study sheds light on some characteristics at the scientific field level and examines their influence on scientist behaviors in material transfer transactions. By doing so, we aim to offer policy implications to adequately address the issues in material transfer and to facilitate academic science.

2. Conceptual background

2.1. Field specificity

The previous literature has shown various impeding factors of material transfer. Thus far, they have shed greater light on factors at the levels of individual scientists and transactions of material transfer; such as involvement in commercial activities, funding sources, extent of competition, and performance of scientists (e.g., Blumenthal et al., 1997; Vogeli et al., 2006; Walsh et al., 2007). However, behavioral characteristics of scientists can be fundamentally influenced by environment, so under different circumstances, decision making on material transfer can be different. Hackett (1990) argues that normative structure which governs behaviors of scientists can vary according to historical period, organizational context, changing institutional environment and scientific field. For example, respective research organizations may formulate their own rules, provide unique training programs, and establish different sets of infrastructure for industry collaboration, commercial activities, material transfer, and so forth. These would shift values of scientists to different directions. Among other factors, we assume that scientific fields can greatly influence behaviors of scientists. Whitley (1984) suggests that different fields have various degrees of mutual dependence between scientists and task uncertainty, which results in variations of knowledge structures and patterns of its change. Furthermore, levels of scientific competition (Hagstrom, 1974), maturity of science (Crane, 1972), marketability of technologies, size of research expenditure, and mobility of scientists, and other various factors can vary with fields. We assume that these numerous differences influence values and behavioral patterns of scientists and can change the effects of the impeding factors of material transfer. Some studies have shown potential differences between scientific fields

(e.g., Campbell et al., 2002), but our understanding of background mechanism is still limited. Thus, we aim to extend our knowledge by shedding light on field differences.

2.2. Commercialism and reciprocity

2.2.1. Behavioral characteristics of academic scientists

In this section, before arguing field-level environment, we discuss two types of behavioral characteristics of academic scientists which can impede material transfer.

Market-oriented behavior. Traditionally, the norms of communism have supposed that academic scientists should attain their satisfaction primarily from recognition and esteem for their scientific achievement, and thus, that they should give up property rights of their discoveries (Merton, 1973). In other words, academic scientists should provide their research materials without condition for those who need them. However, a competing argument has been developed that academic scientists have turned market-oriented or commercialized, and attached more importance to private property rights (Dasgupta & David, 1994; David, 2003). Recent transition of social environment and science policy has shifted emphasis to practical application of academic research. As a result, increasing number of scientists have been engaged in commercial activities and industry collaboration. In the early days of this trend, academic scientists who participated in commercial activities were disapproved by their peers. However, along with various institutional transitions (e.g., implementation of Bayh–Dole Act in the US and similar laws in other countries), academic entrepreneurship has achieved a certain status (Etzkowitz, 1990). This trend has accelerated the flow of knowledge and expertise from the academia to the society (Slaughter & Leslie., 1997), but simultaneously, scientists have become more concerned about monetary values

produced through their research. This has impeded flow of knowledge and technologies of the academia. For example, when scientists receive industry funds or collaborate with industry researchers, they tend to withhold research materials and data (Blumenthal et al., 1997; Campbell et al., 2002). Scientists who have applied patents tend to be secretive (Campbell, Weissman, Causino, & Blumenthal, 2000; Hou, Kretschmer, & Liu, 2008). Academic scientists involved in commercial activities, such as licensing and founding companies, often deny sharing their research materials and data (Campbell et al., 2002; Walsh et al., 2007), delay and withhold publication (Blumenthal et al., 1997), and hesitate verbal communication (Blumenthal et al., 2006). Thus, these market-oriented behaviors have formed an important part of behavioral characteristics of recent academic scientists.

Reciprocal behavior. Although numerous studies blame the recent proprietary regime of the academia for deteriorating the traditional norms of communism, the literature also suggests that academic cooperation had been impeded for anti-communal reasons even in pre-commercialism time. Along with the norms of communism, Merton (1973) admits that competition for priority of scientific discoveries is fundamental motivation of academic scientists, which can facilitate scientists to behave in a secretive manner.

Priority is extremely important for academic scientists because only the first scientist who makes a certain discover can earn esteem from their peers. This not only gives satisfaction to scientists in itself, but also it expands the future of scientists. High recognition may enable scientists to obtain large research funds, create promising collaboration, attract excellent students, find academic positions, earn high salaries, and so forth, and all of them further increase the possibility of their academic success (Cohen & Walsh, 2008; Dasgupta & David, 1994). Thus, a desire for obtaining priority is inevitably

intense. Basically, this leads to efficient research process and swift publication, which has secured healthy advancement of science. However, the benefit of priority for individual scientists is so great that academic scientists sometimes attempt to achieve it at the sacrifice of benefit of the academia. Stephan (1996) suggests that the race for priority hinders academic scientists from disclosing and sharing their research. To ascertain priority, scientists delay publication and withhold key information from publication (Hagstrom, 1974), and deny sharing research output with other scientists (Walsh et al., 2007).

With these taken into consideration, behaviors of scientists are governed not just by a desire for recognition, but perhaps more importantly by a desire to achieve their personal benefit in various forms. We assume that this leads to another behavioral characteristic in scientist cooperation. That is, scientists expect certain forms of return to improve their recognition when providing their capabilities and resources for other scientists. They may strategically choose consumer scientists who offer the maximum return. Typical return is coauthorship, which has been used to give credits to scientists who contribute to a certain publication. Although authorship is a crucial rewarding system in the academia, it is unclear and controversial what extent of contribution scientists should make to be authors. This unclearness allows rational scientists to exploit coauthorship to maximize their recognition. In material transfer, some scientists explicitly demand coauthorship in return for material transfer. In some fields, coauthorship is even nearly a requirement. Other forms of return include acknowledgement, feedback of research data, and so forth. In the long term, supplier scientists may expect future benefit in the relationship with consumers. By providing research material, suppliers can impose obligation on consumer scientists. Thus, while the norms of communism suppose free cooperation, in reality various forms of return

exist explicitly and implicitly. We assume that these reciprocal behaviors have formed another important part of behavioral characteristics of academic scientists. As a preliminary assumption, we hypothesize the following:

Hypothesis 1: *The likelihood of denial for a material transfer increases when a supplier scientist does not believe that the material transfer leads to his or her own benefit.*

2.2.2. Field effect on scientist behaviors

We discussed two directions of behavioral characteristics which can contradict with the traditional norms of communism. However, they are not necessarily dominant in all fields but largely depend on field environment. Thus, based on the above, we discuss how characteristic of scientific fields influence behaviors of academic scientists.

Prevalence of commercialization. First, we assume that the extent of prevalence of commercial activities in a certain field will influence scientist behaviors. The extent of commercialization significantly varies with scientific fields due to marketability of technologies and so forth. For example, biology has turned into commercially-active because of the revolution of biotechnology (Zucker & Darby, 1996). Clinical science has a strong connection with the industry because of the necessity for clinical trials.

When commercialization prevails in a certain field, more scientists are engaged in commercial activities and they tend to behave in an anti-communal way. In addition to this, we assume that even commercially-inactive scientists would be affected by prevalent commercialization. Stuart and Ding (2006) imply that emphasis on commercialization diverts the whole academic norms toward market-oriented one. Once academic scientists

are allowed to supply research materials commercially, more scientists pursue monetary value and higher percentage of material transfer requests may be denied for commercial reasons. Under such circumstances, it would make less sense even for commercially-inactive scientists to comply with the norms of communism, because it allows commercially-active scientists to enjoy free riding whereas they cannot use expertise of commercially-active scientists. To be scientifically competitive, commercially-inactive scientists cannot help using their capabilities and resources as a means to maximize their personal benefit. Thus, they would focus on cooperation which leads to their benefit and avoid that which does not. Thus, in material transfer transactions, we assume that prevalence of commercialization will accelerate the reciprocal behaviors.

Hypothesis 2: Under high prevalence of commercialization, the likelihood of denial for a material transfer is more strongly associated with supplier's benefit.

Reciprocal climate. Second, we assume that the acceptance of reciprocal cooperation in a certain field will influence scientist behaviors. The reciprocal climate also differs due to characteristics of material (e.g., scarcity), degrees of division of labor, and so forth. As reciprocal behaviors are being accepted as standards in academic cooperation, a consensus will be established that capabilities and resources of academic scientists are means to achieve rather their personal goals than holistic advancement of the science. Then, academic scientists would strategically develop and apply their expertise to maximize their own benefit. For example, scientists may develop research tools which can be applied for wide areas of usage, and attempt to provide them to obtain coauthorship. Scientists may supply their research materials only for requests with attractive return. Under high

reciprocal climate, since scientists generally prioritize their own benefit, commercially-active scientists can easily rationalize their withholding behaviors. They will not have to abandon their opportunities to earn commercial income just for securing social benefit any more. Consequently, high level of reciprocal climate in a certain field will aggravate the effects of market-oriented behaviors.

Hypothesis 3: Under high reciprocal climate, the likelihood of denial for a material transfer is more strongly associated with commercial involvement.

Acceptance of commercial return. Commercial income is a peculiar form of return, which is strongly related to commercialism. We assume that scientist behaviors will be influenced by the extent of acceptance of commercial income for academic scientists. The institutional transitions favoring the academic entrepreneurship have enabled academic scientists to earn monetary income as a return for practical application of their research, although literature argues that monetary values degrade academic science.

In actual commercial activities, the flow of commercial income can be complex. When income is produced as revenue of companies, supplier scientists, who are members of companies, will gain financial return through salaries, dividends, and rising stock price. More common income sources include licensing, consulting, and so forth, where the industry usually pays academic scientists for their support. In these cases, research organizations can control the distribution of commercial income to some extent, for example, by taking commissions, restricting maximum hours spent on commercial activities, setting an upper limit of commercial income, and so forth. These rules of financial income distribution can be different due to some reasons; such as forms of

commercial activities, governance of research organizations, and conventions of scientific fields. When high income is distributed to individuals, it will clearly incentivize involvement in commercial activities and withholding behaviors. As expectation for high financial return increases opportunity cost to comply with the communism norms, commercial-active scientists will be more likely to withhold their research. Simultaneously, granting high financial return could send a message that academic scientists could exploit their expertise as their own property. This will strengthen reciprocal behaviors. Thus, high commercial return for individual scientists will reinforce withholding behaviors of commercially-active scientists and reciprocal behaviors of all scientists.

Hypothesis 4a: *Under high acceptance of financial return, the likelihood of denial for a material transfer is more strongly associated with commercial involvement.*

Hypothesis 4b: *Under high acceptance of financial return, the likelihood of denial for a material transfer is more strongly associated with supplier's benefit.*

2.3. Network structure

2.3.1. Relationship of suppliers and consumers

Another essential factor which influences material transfer transactions is scientist network, where consumer scientists search for suitable research materials. The previous literature proposes types of scientist network (Murray, 2004). Among them, one of the important and unique forms for the academia is cosmopolitan network or invisible college. Cosmopolitan network is a broad social context of scientists in a certain discipline (Crane, 1972). It enables academic scientists to obtain diverse expertise, and is indispensable when scientists expand their research over existing framework (Murray, 2004). However, this

network does not necessarily work perfectly. Scientists may hesitate to cooperate with non-acquaintances in the cosmopolitan network, because it takes higher transaction cost and potentially because non-acquaintance scientists can compete with them.

To overcome these limitations of cosmopolitan network, scientists make habitual efforts to increase reliable collaborators through networking activities. They attempt to cultivate weak relationship in cosmopolitan network into stable collaborative relationship in a long term. In respect of stability, another form of network, or laboratory network, is noteworthy (Murray, 2004). As scientists usually spend most of their time in laboratory work, they tend to build stable relationship with their colleagues, supervisors, juniors and seniors. As a source of research materials, these established networks offer clear advantages. Consumer scientists are sure to whom to make a request. They may not have to offer immediate return to their suppliers. Supplier scientists are willing to help them, or at worst hesitate to deny them since it can harm their valuable network. Due to established mutual trust, transaction cost will be small. Of course, scientists may not necessarily find what they need inside their established network, so solely depending on it would restrict the scope of their research. Nevertheless, if consumers can find appropriate research materials in it, established network will be an extremely efficient source. Thus, as a preliminary assumption, we hypothesize the following:

Hypothesis 5: The likelihood of denial for a material transfer decreases when a supplier scientist and a consumer scientist are in a collaborative relationship.

2.3.2. Network structure in different fields

Although laboratory network is an important source of material transfer, dependence on prior laboratory colleagues can greatly differ with fields due to mobility of scientists, turnover of research topics, size of research projects, and so forth. Under intense laboratory network, network members tend to sustain their relationship throughout their careers. When the relationship is stable and long-term oriented, transaction cost to share research materials and make other forms of cooperation will decrease. This facilitates laboratory members to rely more on the network. As the network is sustained for a long term, specific expertise is accumulated in it. Consequently, cooperation within the laboratory network grows increasingly reliable and efficient. On the other hand, once such a solid network is established, cooperation with outsiders will take relatively high transaction cost while suppliers' benefits become less certain. Even though non-communal behaviors can harm scientists' reputation, scientists can still maintain sound positions inside the laboratory network. Thus, we assume that compliance with requests from outsiders decreases as laboratory network grows intense.

Hypothesis 6: Under intense laboratory network, the likelihood of denial for a material transfer is more strongly associated with previous relationship between a consumer and a supplier.

3. Method

3.1. The academia in Japan

For this study, we use a sample of Japanese academic scientists. The Japanese academic environment has been characterized by some factors (Nagaoka, Kondo, Flamm,

& Wessner, 2009). First, it has a long tradition of close ties with industry through various channels such as hosting corporate researchers in universities and receiving donations from firms. Second, until quite recently, academic scientists were able to obtain research funds stably through fixed funding system, while competitive research funds accounted for small part. Third, job mobility of scientists is quite low especially in old generation. Scientists tend to attain academic positions in the same laboratory where they receive degrees and stay there throughout their career. In such laboratories, research topics are succeeded from generation to generation. Thus, relationship between laboratory supervisors and young scholars are fairly important.

The academia in Japan has experienced a drastic environmental change since mid-1990s. In the midst of an economic recession in 1990s, the government considered the academia as a source of innovation and a key player to solve their economic stagnation. In order to facilitate the innovation process in the academia, the government has carried out several reform plans. First of all, it aimed to encourage commercial activities in the academia, for which series of laws have been enforced; such as Japanese Bayh–Dole Act. Second, it intended to promote efficiency of academic research. The government incorporated national universities and public research organizations. Fixed research funds have been decreased while competitive ones have been increased. Third, it aimed to increase the mobility of scientists, for which the government has encouraged research organizations to increase non-tenure positions. As a whole, these series of reform intends to follow the US academic system. Because the reform was implemented relatively recently, the progress of the reform differs from case to case.

3.2. Data

Our data is obtained from two sources: interviews and a survey. First, we conducted interviews of 30 academic scientists. The interviews were semi-structured regarding experience of material transfers, other types of cooperation, network within the academia and with the industry, and opinions about recent policy and organizational interventions. Each interview took from one to two hours.

In parallel with the interviews, we constructed survey instruments on the basis of the previous literature and our interview results. In order to validate the instruments, we conducted a preliminary survey with 40 scientists selected randomly from our population. We also interviewed ten scientists to find unclear or inappropriate questions in the instruments. Then, the revised instruments were mailed to a random sample of 1,972 scientists,¹ and we received 838 responses. The response rate was 43%. The survey was conducted in Feb-Apr of 2009.

Our sample consists of 698 university scientists and 137 PRO scientists. The respondents published 11 papers and applied 1.2 patents in the past two years. The mean research group size was six researchers. On average, they obtained their first degree (Ph.D. or MD) in 1988, since then they have experienced 2.8 laboratories and have been working

¹ As we are interested in academia scientists who actively conduct research, we focused on scientists working in research universities and public research organizations (PROs). In addition, since decisions about material transfer are usually made by laboratory supervisors in Japan, full or associate professors in universities and their equivalent in PROs were chosen (Assistant professors, post-doctors, and students were excluded). Because up-to-date sampling frame satisfying our population was not available, we had to create a sampling frame for this study. For university scientists, we used a database of national research funds (Kaken), whereby we extracted research-active scientists. The database includes all the scientists who have received national funds since 1965. Among them, we chose 8,013 scientists in top 45 universities who received national funds in the last five years in our interest fields. For PROs, we chose nine representative PROs covering our interest areas. Then, we created a scientist list using their website information, which included 695 scientists. From these sampling frames, we randomly selected 1,972 scientists (1,674 from universities and 298 from PROs).

in the current laboratory for 13 years. In terms of scientific fields, our primary focus is life science since material transfer plays an essential role (e.g., Walsh et al., 2007). In addition, we included material science since material transfer seems to play an important role but the previous literature has little focus on it. Those two fields might be environmentally fairly different, so we expect to clearly examine the effect of environmental factors. Our respondents are in the fields of basic biology (19%), basic medicine (19%), clinical science (12%), agricultural science (18%), pharmaceutical science (11%), medical engineering (4%), and material science (17%).² These fields are further subdivided into 16 subfields. Appendix 1 describes details of scientific fields.

3.3. Measures

Independent variables. First, we construct four field-level measures for 16 scientific subfields; (1) *reciprocal climate*: the number of material transfer requests which supplier scientists believed to result in coauthorship is divided by the number of all the requests; (2) *prevalence of commercialization*: the number of commercially-active scientists divided by the number of all the scientists; (3) *acceptance of commercial income*: an average of the ratio of financial income distributed as personal income in the last two years; (4) *laboratory network intensity*: an average of the ratio of laboratory members who obtained their degrees in the same laboratory.³ Next, we prepare three variables about

² Scientific field of each respondent was determined by the database of national research funds. The database records in what scientific field each scientist has obtained research funds in the past. We chose one field for each scientist which is most frequently assigned.

³ In Japanese research organizations, job mobility of scientists is fairly low. Thus, we assume that we can estimate the intensity of laboratory network by the ratio of its graduates in the laboratory. In case that job mobility is high, different measures should be used; such as ratio of prior laboratory members in all collaborators.

characteristics of supplier scientists and transactions of material transfer; (1) *no return expectation*: if a supplier believes that a material transfer does not lead to coauthorship, a dummy variable is coded one; (2) *non previous collaborator*: if a consumer is not a previous collaborator or laboratory members of a supplier, a dummy variable is coded one; (3) *commercial involvement*: if a supplier is involved in at least one form of commercial activities, a dummy variable is coded one. Commercial activities include negotiation with the industry, foundation of new firms, development of new technologies in market, and earning licensing income.

Dependent variables. For the respondents who have received at least one material request from other academic scientists in the last two years, we construct two dependent variables to measure denial of requests. The first is the number of denial for material transfer requests in two years (*#denial*). The second is a dummy variable, which is coded one if a respondent denied the latest material request (*denial for the latest request*).

Control variables. We include several control variables on the basis of the previous literature. First, the number of requests is controlled as a measure of overall burden (*#request*). Second, budget amount is controlled, because it increases the capacity of handling material requests (*\$ funding*). Of this amount, the ratio of industry funding is controlled since it is known as a major impediment to material transfer (*% industry funding*) (Campbell et al., 2002). Third, the number of publication is controlled because scientists with higher performance have to pay greater opportunity cost to comply with material requests (*#publication*) (Walsh et al., 2007). Fourth, competition between a consumer and a supplier is controlled, because it discourages the supplier from cooperating the consumer. If a supplier believes that a consumer's research can compete with supplier's,

a dummy variable is coded one (*likelihood of competition*). Fifth, other demographic factors are controlled; *full professor* is coded one if a respondent is a full professor; *tenure track* is coded one for a respondent in tenure track, the number of years after obtaining degrees is controlled (*career*); *private school* is coded one for a respondent in private school, and *PRO* is code one for a respondent in a public research organization.

4. Results

4.1. Description and bivariate analysis

First of all, we show basic description in terms of material transfer transactions. As for the frequency of material transfer, 58 % of our respondents have made at least one material transfer request in the last two years, and 59% have received at least one request in the same period. On average, they made 2.7 requests and received 5.5 requests in two years. These figures are relatively small in comparison with the previous studies on US scientists (e.g., Walsh et al., 2007). As for the ratio of fulfillment and denial, 10% of the requests they made were not fulfilled, while they denied 8% of requests they received. These figures are smaller than that of the current US (Walsh et al., 2007), but are comparable with that of the US 10 years ago (Campbell et al., 2002).⁴

Next, Table 1 describes several characteristics related to material transfer, and compares the denial ratio of material transfer to examine the potential impediments and facilitators. First, regarding commercial involvement and industry relationship, 49% of our

⁴ This comparison needs caution because the definition of research material is different: whereas the previous studies include sharing of data, etc., we counted transfer of physical research materials only.

respondents receive industry funds. The industry funds account for 9% of their total research funds. Forty-five percent of scientists have applied at least one patent in the last two years. On average they applied 1.24 patents. Moreover, 32% of scientists have been engaged in a certain type of commercial activities; including negotiations over rights to their technologies with the industry (28%), foundation of new firms or marketing new technologies (7%), and out-licensing of their technologies (7%). To examine the effects of these factors, we conducted T-tests to compare denial ratios. The results show that patented materials are less likely to be supplied than non-patented materials (13% vs. 7%; $p < 0.1$). Among a few forms of commercial activities, involvement in early-stage commercial activities (e.g., negotiation with the industry) increases denial ratio significantly (15% vs. 8%; $p < 0.05$). Other factors are statistically insignificant, but the data generally implies that industry relationship and commercial involvement slightly increases the denial ratio.

Second, regarding return for material transfer, our respondents expected that 48% of material requests they received would result in coauthorship and 24% in acknowledgement. They also expected that 39% of the requests would lead to some forms of benefit in the long term. T-tests show that these expectations significantly decreases denial ratio; coauthorship (5% vs. 17%; $p < 0.001$), acknowledgement (7% vs. 17%; $p < 0.05$), and long-term benefit (and 5% vs. 12%; $p < 0.01$). On the other hand, if suppliers expect nothing in return, they are significantly more likely to deny such requests (17% vs. 6%; $p < 0.001$). These results are supportive to Hypothesis 1.

Third, in terms of relationship between a consumer and a supplier, on average 31% of requests were made by previous collaborators and laboratory colleagues, and 40% were made by complete non-acquaintances. T-tests show that the probability of denial to requests

from previous collaborators is significantly small (2% vs. 12%; $p < 0.001$). This result is supportive to Hypothesis 5. It also shows that requests from non-acquaintances are slightly more likely to be denied than from acquaintances without collaborative experience (15% vs. 10%; $p < 0.1$).

In addition, possibility of competition between a consumer and a supplier seems to increase denial ratio although this effect is not significant (15% vs. 8%; n.s.). When a supplier scientist is in tenure track, the denial ratio is significantly higher (11% vs. 3%; $p < 0.01$). Organizational types do not affect the denial ratio significantly.

4.2. Field difference

Table 2 describes field characteristics from four perspectives: commercial prevalence, reciprocal climate, acceptance of commercial income, and laboratory network intensity. The data indicates that these characteristics are significantly different between subfields.

First, in terms of the prevalence of commercial activities, about half of scientists are engaged in certain commercial activities in the subfields of medical engineering (67%), molecular biology (50%), material chemistry (45%), while less than 20% of scientists are commercially-active in the subfields of agricultural science (17%), basic biology (18%), and neuroscience (19%). The interviews suggest that in the medical engineering subfield, the academia and the industry is closely linked because output of academic research is often applied for medical use; such as regenerative cells and artificial organs, and that they have plenty of opportunities for commercialization. In the molecular science subfield, commercialization has been prevailing in these years. Some of our interviewees have just

started up their own business. In the material science field, industry relationship has been historically intense. While industry researchers provide practical ideas for application of academic research, academic scientists are often requested trial-use of materials developed by the industry. Material scientists not only pursue academic success but also are highly motivated to apply their research for the society.

Second, the extent of reciprocal climate, measured by the ratio of material transfer transactions which suppliers believed to result in coauthorship, ranges from 24% in the basic biology subfield to 65% in the veterinary science subfield. Other high reciprocal climate fields include material science and clinical science (approximately 60%). Our interviewees in the compound chemistry subfield mentioned that invention of new materials is their primary goal so material transfer definitely results in coauthorship. In addition, obtaining data about their materials from consumers is another motivation to share materials. In the clinical science field, interviewees suggested that reciprocal cooperation is taken for granted. They mentioned that coauthorship is nearly always given regardless of the importance of supplier's contribution. Without coauthorship, they would never cooperate. If a consumer had not granted coauthorship after receiving a material, such a consumer would be blacklisted. On the other hand, in basic biology subfield, material transfer does not usually lead to coauthorship. Interviewees mentioned that coauthors must do experiments for specific publications. They explained that material transfer is a duty of academic scientists and that even a request from competitors must be fulfilled.

Third, as for acceptance of commercial income, less than 10% is distributed to personal income in some subfields, while 30-50% goes to individual scientists in the basic medicine field and 75% in the agricultural science subfield. An interviewee explained that

his university takes 30% of commercial income and 70% goes to related departments. Departments may give part or all of the 70% to suppliers' laboratory budget but none of it goes to personal income. This distribution rule differs case by case.

Fourth, laboratory network intensity is high in the fields of clinical science and agricultural science, where approximately half of the scientists stay in the same laboratory after receiving degrees. On the other hand, it is low in the fields of basic biology and material science. Interviewees in the clinical science field mentioned that their laboratory network is fairly solid and lasts long even after changing affiliations. Most collaboration takes place inside the network because essential resources are easily found there. Collaboration with outsiders rarely occurs. In the fields of material science and basic biology, interviewees mentioned that they are changing research topics and affiliations occasionally so that previous colleagues are not generally helpful in their current research. They also mentioned that they have never collaborated with previous colleagues but receive mental stimulus from them.

4.3. Hypothesis testing

Table 3 shows results of regression analyses for the hypotheses.⁵ Appendix 2 shows a statistical description and correlation matrix of the variables.

In Model 1.1-1.4, Hypotheses 3 and 4a are tested. As their primary independent variable, *commercial involvement*, is an individual-level factor, we use overall denial

⁵ Because calculation and interpretation of interaction effects in nonlinear regression models are not straightforward and can be problematic (Ai & Norton, 2003), I also generated the marginal effects for the interaction terms and ran the models using an ordinary least squares specification instead. These two alternative approaches both generated the same pattern of results.

frequency (*#denial*) as a dependent variable. To deal with this count data, we use negative binomial regressions. Model 1.1 includes only control variables, and Model 1.2 added simple terms of independent variables.

In support of Hypothesis 3, Model 1.3 shows that the interaction term between *reciprocal cooperation* and *commercial involvement* has a significantly positive effect ($b=4.13$, $p<0.1$). Figure 1(A) indicates that when reciprocal climate is weak, the number of denial decreases due to commercial involvement (0.53 vs. 0.24).⁶ On the other hand, when reciprocal climate is prevalent, the number of denial increases due to commercial involvement (0.72 vs. 5.1). Next, in support of Hypothesis 4a, Model 1.4 indicates that the interaction term between *acceptance of commercial income* and *commercial involvement* has a significantly positive effect ($b=3.65$, $p<0.05$). Figure 1(B) indicates that when low percentage of financial income is distributed to individuals, the number of denial slightly decreases due to commercial involvement (0.35 vs. 0.10). On the other hand, when high percentage of financial income is distributed, the number of denial increases due to commercial involvement (0.20 vs. 1.1).

In Models 2.1-2.5, the rest of Hypotheses are tested. As part of their independent variables is at the level of transactions of material transfer, we use *denial for the latest request* as a dependent variable. To deal with the binary dependent variable, Logit regressions are used. Model 2.1 includes only control variables, and Model 2.2 adds simple terms of independent variables. In support of Hypothesis 1, the model shows that when coauthorship is not expected, the probability of denial increases ($b=1.09$, odds ratio=3.0;

⁶ Predictions are made with field-characteristic variables at their mean ± 2 s.d., other independent variables at 0 and 1, and all other variables at their means.

$p < 0.05$). In support of Hypothesis 5, the model also shows that when a consumer is not a previous colleague, the probability of denial increases ($b = 1.32$, odds ratio = 3.7; $p < 0.05$).

In support of Hypothesis 2, Model 2.3 shows that the interaction term between *prevalence of commercialization* and *no return expectation* has a significantly positive effect ($b = 7.52$, $p < 0.05$). Figure 1(C) shows that when commercialization is not prevalent, it makes small difference in the probability of denial whether coauthorship is expected or not (1.9% vs. 0.8%). However, when commercialization prevails, material requests which do not lead to coauthorship are highly likely to be denied (0.5% vs. 7.3%). Model 2.4 does not show a significant effect of the interaction term between *acceptance of commercial income* and *no return expectation*. Thus, Hypothesis 4b is rejected. In support of Hypothesis 6, Model 2.5 shows that the interaction term between *laboratory network* and *non previous colleague* has a significantly positive effect ($b = 9.94$, $p < 0.05$). Figure 1(D) indicates that when laboratory network is weak, the probability of denial slightly decreases when a consumer is not a previous collaborator (3.0% vs. 1.5%). On the other hand, when laboratory network is intense, requests from non-colleagues are more likely to be denied (0.0% vs. 3.7%).

5. Discussion

Using a sample of Japanese academic scientists, this study examines behavioral patterns of scientists in material transfer with the influences of field characteristics taken into consideration.

First, this study shows that not only the market-oriented behaviors but also the reciprocal behaviors function as drivers of academic scientist which contradict with the traditional norms of communism. In some fields scientists tend to demand some forms of return when supplying research materials. They are less likely to provide their materials if their benefits are not clear. Typically, they demand coauthorship. Our interviewees suggested that coauthorship is even a requirement for material transfer in some fields although the rule of authorship is unclear in most cases. One of our interviewee mentioned that some of his suppliers greedily demanded first or last authorship, which implies the highest contribution in his field, just by supplying a material, and that he decided never to support these greedy scientists if requested. Thus, these behavioral patterns emphasizing reciprocity may deteriorate the cooperative relationship in the academia. Our results suggest that if reciprocal climate prevails in a field, it can even aggravate the side effect of commercialism. That is, reciprocal climate can justify self-benefit oriented behaviors, which especially facilitates commercially-active scientists to prioritize monetary values for their own sake.

In this respect, although the previous literature implies potential benefit of rewarding system to facilitate academic cooperation, it requires utmost caution. Niu (2006) explains that current policy interventions are based on punishment rather than on rewarding (e.g., mandatory data sharing of NIH grants), and suggests that reward-based system can be more efficient than punishment-based one. However, such rewarding system must be delicately designed so that it gives a reasonable incentive for cooperation but does not encourage excessively demanding behaviors.

Second, this study examines the effect of prevailing commercialism at the field level. The previous literature has cautioned that commercially-active scientists tend to be non-compliant with free research sharing (Campbell et al., 2002; Walsh et al., 2007). In addition to this, the results imply that when commercialization prevails at the field level, it can create a climate which encourages scientists to prioritize their personal benefit. Then, even commercially-inactive scientists come to withhold their research materials unless reasonable return is expected. Thus, although academic entrepreneurship is a potential mechanism to expand practical application of academic research, it could deteriorate very basic cooperative relationship inside the academia. Coupled with the first point, the trend of commercialization and the climate of reciprocity can reinforce each other and lead to anti-communal consequences.

As a potential intervention to alleviate this problem, this study examines the influence of distribution of commercial income. Research organizations can control the flow of commercial income to some extent. The results indicate that when large percentage of commercial income is distributed as scientists' personal income, they come to withhold their research material. On the other hand, when personal income is restricted, they seem to lose incentive to protect commercial values and tend to comply with material requests. Thus, appropriate control of commercial income by research organizations might solve the side effects of commercialism. Here, we should be cautious because such an intervention can deter policy intention to facilitate practical application of academic research. Thus, future research should examine a balanced intervention both to maintain the communism values and to facilitate practical application of academic research.

In this respect, further analysis of our data implies that low commercial income distribution does not discourage scientists from being involved in commercial activities. Thus, commercially-active scientists might not be so strongly motivated by monetary values, but they might be motivated by a desire to contribute to the society directly. One of our interviewees who involves in commercial activities mentioned that the purpose of her commercial activities is not earning money but diffusing her technologies, and that she has never denied material transfer for commercial reasons.

Third, this study examines the influence of scientist network on material transfer. The results show that material requests from previous laboratory colleagues and collaborators are significantly more likely to be fulfilled than those from non-acquaintances. Clearly, transactions between non-acquaintances take higher cost, so scientists may have less incentive to support them. Our interviewees mentioned that they could not sometimes tell how promising the research of non-acquaintance consumers is, and that they hesitated to supply their precious materials without being convinced of consumer's success.

To overcome this barrier of network, scientists make great efforts to expand and establish their network. However, the results also suggest that excessively established network can lead to negative side effects. We found that some fields are characterized by narrowly restricted scientist network, where cooperation with outsiders is unlikely to occur. This could lead to fragmentation of scientific fields and impede cross-fertilization of science. Therefore, interventions to loosen network density can be a solution to facilitate material transfer and scientist cooperation. Again, we must be careful in that these interventions might potentially result in redundant research and less diversity (Dasgupta &

Maskin, 1987). Future research should examine the balance between scientist cooperation and diversity of research.

The results of this study must be considered in the context of the following limitations. First, this study uses Japanese scientist data, which restricts the possibility of generalization. Also, we focused mainly in fields of life science and material science. Although our concepts are universal, we need to replicate this study for greater external validity. Second, although we assume that environmental differences are primarily attributable to scientific fields, they can stem from other factors. Thus, it would be necessary to reexamine our discussion from different angles. Organizational background is one of such factors, though our analysis about organizational factors did not reveal great differences.

In conclusion, this study implies that characteristics of scientific fields, such as commercial prevalence and laboratory network, differentiate behavioral patterns of academic scientists. Thus, we should take such factors into consideration to design appropriate policy interventions to facilitate scientist cooperation.

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Table 1 Environment of material transfer ^a

	% Yes	Denial ratio		T-test
		Yes group	No group	
Commercial activity & industry relationship				
Industry fund	49%	10%	8%	n.s.
Having applied patents	45%	11%	7%	n.s.
Requested material is patented	21%	13%	7%	†
Commercial activities (all types)	32%	10%	8%	n.s.
Early stage (negotiation & feasibility study) ^b	28%	15%	8%	*
Late stage (start-up & new technology on market) ^b	7%	2%	8%	n.s.
Licensing income ^b	7%	8%	8%	n.s.
Return of material transfer				
Material transfer leads to a certain form of return	77%	6%	17%	***
Material transfer leads to coauthorship ^c	48%	5%	17%	***
Material transfer leads to acknowledgement ^c	24%	7%	17%	*
Material transfer leads to future benefit	39%	5%	12%	**
Prior relationship				
Request from previous collaborator or laboratory colleague	31%	2%	12%	***
Request from complete non-acquaintance ^d	40%	15%	10%	†
Misc.				
Consumer's research can compete supplier's research	9%	15%	8%	n.s.
A supplier is in tenure track	71%	11%	3%	**
A supplier is in a private school	8%	12%	8%	n.s.
A supplier is in a public research organization	16%	10%	8%	n.s.

^a T-tests include the respondents who have received at least one request in the last two years. N=500.

† p<0.10; * p<0.05; ** p<0.01; *** p<0.001.

^b Comparison between commercially-active scientists in each type and commercially-inactive scientists.^c Comparison between requests with return in each form and requests without return.^d Comparison between non-acquaintances and acquaintance without collaborative experience.

Table 2 Field characteristics ^a

Field	Subfield	Commercial prevalence	Reciprocal climate	Acceptance of financial income	Laboratory network intensity
Basic Biology					
	Molecular Science	0.50	0.63	0.19	0.23
	Basic Biology	0.18	0.24	0.00	0.29
	Biological Science	0.22	0.30	0.10	0.25
Basic Medicine					
	Neuroscience	0.19	0.64	0.50	0.28
	Fundamental Medicine	0.25	0.49	0.36	0.36
Clinical Science					
	Internal Clinical Medicine	0.40	0.56	0.08	0.52
	Surgical Clinical Medicine	0.26	0.59	0.00	0.67
Agricultural Science					
	Agricultural Science	0.17	0.42	0.75	0.40
	Agricultural Chemistry	0.41	0.45	0.11	0.57
	Veterinary Science	0.27	0.65	0.04	0.49
Pharmaceutical Science					
		0.39	0.52	0.01	0.31
Medical Engineering					
		0.67	0.50	0.25	0.31
Material Science					
	Nano Science	0.38	0.57	0.00	0.29
	Compound Chemistry	0.40	0.64	0.08	0.26
	Material Chemistry	0.45	0.47	0.21	0.21
	Material Science	0.35	0.60	0.24	0.22
ANOVA F-test		***	*	*	***

^a ANOVAs test the differences between 16 subfields for four field characteristics. * p<0.05; ** p<0.01; *** p<0.001. Highest three subfields are shaded for respective characteristics.

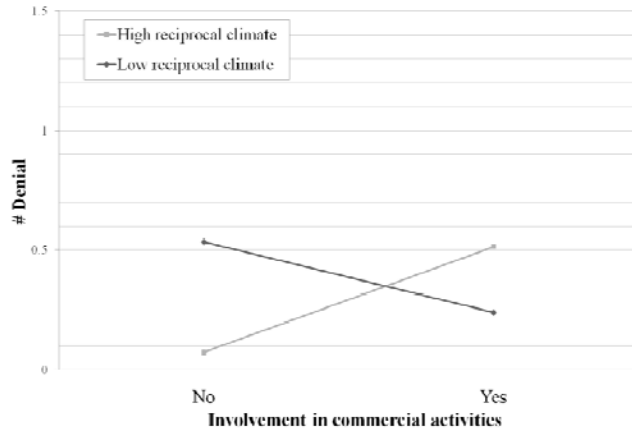
Table 3 Regression analysis^a

	# Denial				Denial for the latest request				
	Model 1.1	Model 1.2	Model 1.3	Model 1.4	Model 2.1	Model 2.2	Model 2.3	Model 2.4	Model 2.5
Control variables									
# Request	0.01 (0.01) *	0.01 (0.01) †	0.01 (0.01) †	0.01 (0.01)	-0.21 (0.08) *	-0.20 (0.07) **	-0.20 (0.07) **	-0.20 (0.07) **	-0.20 (0.07) **
\$ Funding	-0.06 (0.09)	-0.03 (0.03)	-0.07 (0.09)	-0.08 (0.09)	-0.25 (0.15) †	-0.35 (0.17) *	-0.38 (0.17) *	-0.36 (0.17) *	-0.34 (0.17) †
%Industry funding	-0.01 (0.01)	-0.01 (0.01)	-0.02 (0.01)	-0.01 (0.01)	0.00 (0.01)	0.00 (0.02)	0.00 (0.02)	0.00 (0.02)	0.00 (0.02)
# Publication	0.01 (0.01)	0.02 (0.01) †	0.01 (0.01)	0.02 (0.01) †	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
Full professor	-0.49 (0.31)	-0.52 (0.30) †	-0.60 (0.31) †	-0.54 (0.30) †	1.06 (0.44) *	1.19 (0.50) *	1.30 (0.52) *	1.18 (0.49) *	1.17 (0.50) *
Tenure track	-0.02 (0.26)	-0.03 (0.26)	0.02 (0.27)	-0.06 (0.26)	0.86 (0.52) †	0.98 (0.55) †	1.06 (0.58) †	0.96 (0.55) †	0.93 (0.55) †
# Years of Career	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)	-0.04 (0.03)	-0.05 (0.03)	-0.05 (0.03) †	-0.04 (0.03)	-0.04 (0.03)
Private school	0.54 (0.39)	0.50 (0.40)	0.46 (0.37)	0.65 (0.39) †	0.02 (0.68)	0.25 (0.68)	0.26 (0.66)	0.27 (0.68)	0.28 (0.69)
PRO	-0.26 (0.47)	0.28 (0.55)	0.45 (0.55)	0.36 (0.54)	-0.27 (0.62)	0.09 (0.75)	0.04 (0.77)	0.14 (0.75)	-0.30 (0.86)
Likelihood of competition					1.23 (0.55) *	1.27 (0.53) *	1.30 (0.57) *	1.26 (0.53) *	1.18 (0.54) *
Field characteristics									
Prevalence of commercialization		-0.95 (1.16)	-0.23 (1.13)	-0.48 (1.09)		2.05 (1.96)	-2.78 (2.48)	2.11 (1.96)	2.05 (1.87)
Laboratory network intensity		1.83 (1.02) †	2.15 (1.01) *	2.05 (1.00) *		1.23 (1.57)	0.78 (1.61)	1.31 (1.58)	-8.42 (4.20) *
Reciprocal climate		-1.00 (1.24)	-2.51 (1.55)	-0.99 (1.16)		-1.54 (1.95)	-2.06 (1.99)	-1.35 (1.93)	-1.31 (1.92)
Acceptance of financial income		0.17 (0.68)	0.43 (0.72)	-1.02 (0.82)		-0.54 (1.17)	-0.78 (1.26)	0.63 (1.78)	-0.44 (1.23)
Scientist / transaction attributes									
Commercial involvement		0.32 (0.26)	0.32 (0.26)	0.25 (0.25)		0.66 (0.47)	0.61 (0.47)	0.65 (0.48)	0.57 (0.48)
No return expectation [H1]						1.09 (0.47) *	0.97 (0.40)	1.10 (0.47) *	1.06 (0.46)
Non previous colleague [H5]						1.32 (0.64) *	1.48 (0.65) *	1.30 (0.64) *	2.36 (0.85) **
Interaction term									
Prevalence of commercialization * No return expectation [H2]							7.52 (3.23) *		
Reciprocal climate * Commercial involvement [H3]			4.13 (2.24) †						
Acceptance of financial income * Commercial involvement [H4a]				3.65 (1.43) *					
Acceptance of financial income * No return expectation [H4b]							-1.65 (2.29)		
Laboratory network intensity * Non previous colleague [H6]									9.94 (4.09) *
N	473	473	473	473	409	409	409	409	409
χ^2 test	26.06 **	34.19 **	35.15 **	38.97 ***	21.38 *	36.61 **	37.81 **	37.17 **	40.37 **
Log likelihood	-312	-310	-309	-307	-101	-90.3	-88.3	-90.1	-88.2

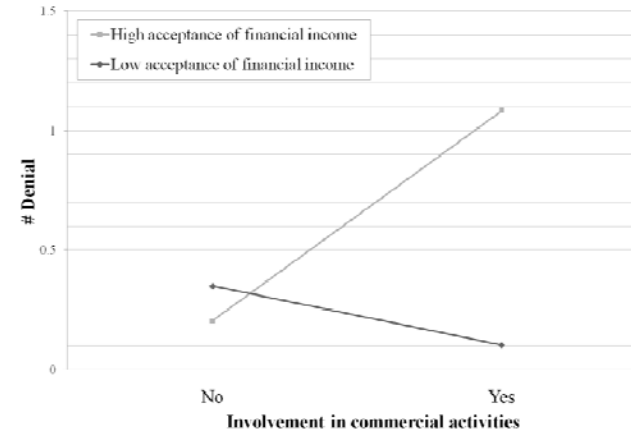
^a Unstandardized coefficients and standard errors (parentheses) are shown. Independent variables are centered before computing interactions. † p<0.10; * p<0.05; ** p<0.01; *** p<0.001. Two-tailed test.

Figure 1 Interaction Plot ^a

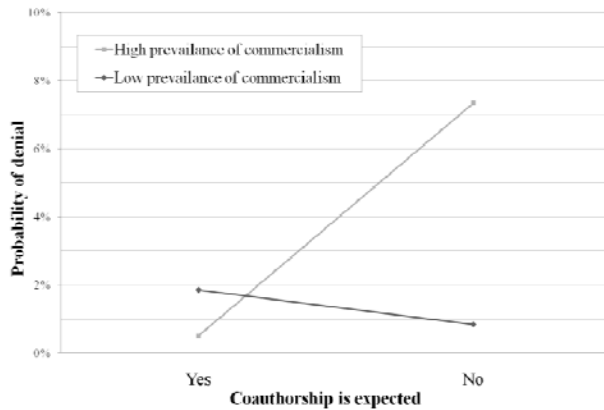
(a) H3: Reciprocal climate * Commercial involvement



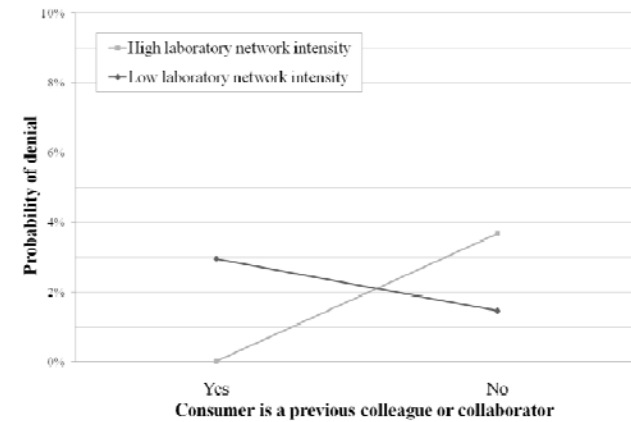
(b) H4a: Acceptance of commercial income* Commercial involvement



(c) H2: Prevalence of commercialization * No return expectation



(d) H6: Laboratory network intensity * Non previous colleague



^a The interacting plots are depicted with keeping all variables at their means except for interacting variables. Dark lines represents low level (mean minus 2 s.d.) and light lines high level (mean plus 2 s.d.).

Appendix 1 Description of scientific fields

Field	N	Examples of research areas
Basic Biology	158	
Molecular Science	18	Living organism molecular science
Basic Biology	74	Genome science, genetics, physiology
Biological Science	66	Biochemistry, biophysics, cell biology, developmental biology
Basic Medicine	157	
Neuroscience	47	Neuroanatomy, neuropathology, Neurochemistry, neuropharmacology
Fundamental Medicine	110	Pathology, pharmacology, medical chemistry, virology, immunology, bacteriology
Clinical Science	103	
Internal Clinical Medicine	60	Circulatory organs, digestive organs, respiratory organs, hematology
Surgical Clinical Medicine	43	Orthopaedic surgery, cerebral neurosurgery, ophthalmology, urology
Agricultural Science	148	
Agricultural Science	29	Breeding studies, plant pathology, applied entomology
Agricultural Chemistry	69	Applied microbiology, applied Biochemistry, applied molecular cell biology
Veterinary Science	50	Animal science, veterinary science
Pharmaceutical Science	89	Chemical pharmaceutical science, biological system pharmaceutical science
Medical Engineering	34	Biomedical engineering, biological material studies
Material Science	146	
Nano Science	32	Nano structural science, nano materials, nano bioscience
Compound Chemistry	34	Polymer chemistry, functional material chemistry
Material Chemistry	35	Inorganic industrial material, polymer/textile materials
Material Science	45	Composite materials/physical properties, inorganic material/physical properties

Appendix 2 Description and correlation matrix ^a

	Mean	s.d.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1. Denial for the latest request	0.08	0.27	0.00	1.00																			
2. # Denial	0.36	1.08	0.00	10.00	0.24																		
3. # Request	9.35	32.27	0.00	400.00	-0.07	0.24																	
4. \$ Funding	3.06	1.51	1.00	7.00	-0.10	0.00	0.18																
5. %Industry funding	7.04	12.78	0.00	80.00	-0.03	-0.02	-0.05	0.02															
6. # Publication	11.76	11.04	0.00	100.00	0.02	0.17	0.11	0.33	0.20														
7. Full professor	0.63	0.48	0.00	1.00	0.06	-0.09	0.05	0.29	-0.01	0.15													
8. Tenure track	0.69	0.46	0.00	1.00	0.12	-0.01	0.00	-0.04	-0.04	0.06	0.13												
9. # Years of Career	21.38	7.69	5.00	57.00	-0.02	0.03	-0.01	0.07	0.06	0.13	0.45	0.13											
10. Private school	0.08	0.28	0.00	1.00	0.01	0.13	-0.01	-0.06	-0.01	0.03	0.03	0.06	0.11										
11. PRO	0.14	0.35	0.00	1.00	0.03	-0.05	0.05	0.24	-0.11	-0.03	0.34	-0.02	-0.16	-0.13									
12. Likelihood of competition	0.10	0.29	0.00	1.00	0.08	0.13	0.00	-0.04	0.09	-0.02	0.02	-0.02	0.02	-0.04	0.06								
13. Prevalence of commercialization	0.32	0.12	0.07	0.67	0.08	-0.04	-0.01	0.12	0.21	0.20	0.04	0.10	-0.07	0.01	0.18	0.01							
14. Laboratory network intensity	0.32	0.15	0.00	0.67	0.01	0.08	-0.02	-0.18	0.11	0.01	-0.23	-0.06	0.12	0.12	-0.68	0.03	-0.12						
15. Reciprocal climate	0.47	0.13	0.00	0.70	-0.01	-0.03	-0.06	-0.01	0.17	0.15	-0.02	-0.05	-0.04	0.11	-0.18	0.02	0.34	0.27					
16. Acceptance of financial income	0.18	0.19	0.00	0.75	-0.02	0.05	0.04	0.02	-0.11	-0.02	0.04	-0.05	0.04	-0.01	-0.03	-0.03	-0.11	-0.06	0.04				
17. Commercial involvement	0.34	0.47	0.00	1.00	0.04	0.06	0.03	0.19	0.24	0.23	0.10	0.07	0.04	0.03	0.05	0.09	0.28	-0.05	0.13	-0.06			
18. No return expectation	0.50	0.50	0.00	1.00	0.12	-0.04	0.07	0.00	-0.06	-0.09	0.03	0.05	-0.01	-0.07	0.06	0.06	-0.08	-0.07	-0.21	-0.02	-0.11		
19. Non previous colleague	0.70	0.46	0.00	1.00	0.17	0.10	0.07	-0.02	-0.12	-0.10	0.01	-0.02	-0.01	0.02	0.02	0.05	-0.06	0.02	-0.05	-0.04	-0.06	0.30	

^a All values of the correlation matrix greater than .08 are significant at $p < .05$.