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RESEARCH ARTICLE

Professional Networks Effects on Scientific Performance: The Conditioning Role of Status and Context

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Abstract: This paper argues that social networks do not always produce monolithically beneficial impacts on performance (e.g., high productivity). This is to say that their influence is not always predictable and advantageous, as that influence is conditioned by status and context. Even performance in places of science such as research universities is not exempt from this contingent nature of network effects. Inspired by the work of DiMaggio and Garip (2012) and focused on the professional networks of academic scientists, this paper posits that the influence of such networks on performance (i.e., journal productivity, receipt of science awards) can either be attenuated, muted, or strengthened by professional status (e.g., academic rank) and social context. To gauge the tenability of this claim, quality data from a face-to-face quantitative survey of 105 chemical science professors in top research universities in three East Asian countries were analyzed. The analysis focused on two aspects of professional networks (i.e., having international ties and having ties in non-academic sectors), which have gained salience because of the globalization of science, the prevalence of digital technologies, and the advent of Triple Helix science. To explore how status and context condition networks affect performance, generalized linear regression analyses were performed. Results indicate that networks influence performance mainly through their interplay with status and context. Results also suggest that to understand the influence of networks on performance—even within scientific systems—its interplay with status and context is important to consider. Such consideration aids in generating deeper insights about the social conditions underlying creativity, discovery, and productivity in scientific life, which in turn can lead to fine-tuning concepts and relationships and advance understanding of science as a social activity.

Keywords: professional networks, scientific performance, status, social context

With the rapid advances in the functionalities, quality, and reliability of digital technologies along with the increasing popularity of social media (e.g., Facebook), internet-based conferencing (e.g., Zoom), and instant messaging (e.g., Viber) software, social networking as a strategy to enhance social capital has also been on the rise. Even academic scientists have not been exempted from applying this trending strategy. In the era of Triple Helix science (Etzkowitz & Leydesdorff, 1995), it is commonplace for academics to have professional networks that span disciplinary (e.g., biology, chemistry), sectoral (i.e., academic, corporate, government), and national boundaries.

In scientific life, professional networks are the web of social relationships (or ties) and the set of others (or alters) that a scientist (or ego) is embedded in and interacts with closely without necessarily having to work on a project or toward specified goals. More concretely, professional networks are the set of ties with individuals with whom a scientist consults, discusses, and shares important concerns and matters pertaining to scientific work, including personal matters. This set of individuals transcends group, disciplinary, locational, organizational, sectoral, and status-related boundaries. Professional networks are generally more affective than instrumental, informal than formal, and trust- than contractual-based (Ynalvez & Aviles, 2021; Ynalvez & Shrum, 2011).

Science is conducted in corporate R&D labs, government research labs, and research universities (Etzkowitz & Leydesdorff, 1995), and scientists occupy positions (or social status) as indicated by academic rank in the context of universities. Even in formal, meritocratic, and rational systems that typically characterize modern places of science, social status and social context influence performance, such as productivity and recognition (Hong & Zhao, 2016; Van Miegroet & Glass, 2020). In general, however, performance is also influenced by factors beyond context and status, of which professional networks are one such influential factor. However, despite the salience of professional networks in science, it remains an understudied phenomenon in the sociology of science (Hong & Zhao, 2016; Ynalvez & Shrum, 2011). Of the few studies focusing on professional networks, most emphasized their direct and independent effect on performance. Very few studies focused on how status and context moderate the influence of professional networks on scientific performance.

This present study addresses the knowledge gap described above. It explores how the impact of two compositional aspects of scientific professional networks (i.e., having non-academic ties and having international ties) on scientists' receipt of science awards and the number of articles generated are conditioned by social context (location) and professional status (academic rank). This study's core hypothesis: professional networks' influence on scientific performance is mainly through their interplay with scientists' academic rank and the larger sociocultural context in which scientists are embedded. This conditioning of network effects by status and context can either improve or impede scientists' performance.

This paper contends that social networks do not always produce a monolithically beneficial impact on social performance (e.g., high productivity, high recognition). This is to say that the influence of networks on performance is only sometimes advantageous and predictable because that influence is conditioned by status and context. As Max Weber argued, status is critical in determining status attainment and performance (Grusky & Hill, 2018). Associated with status are expected behavior, consumption patterns, roles, tastes, styles, and even access to resources and support (Ynalvez & Ynalvez, 2017). In science, academic rank is considered a master status, which has implications on professional demeanor and responsibilities such as teaching, research, and service, including course load, schedule, and time use. Rank is also associated with material resources, support systems, productivity, and recognition. With the salience of status in the form of academic rank, it is argued that status can also moderate or configure network effects on scientific performance.

Several studies have highlighted the importance of context in scientific productivity and recognition (e.g., Collins, 2010; Henke & Gieryn, 2008; Frey, 2007; Ynalvez & Shrum, 2009). Context refers to institutions, locations, settings, or places. It provides academics with the cultural setting, environment, practice, resources, prestige/reputation, and support that can either facilitate or hinder the production, dissemination, and consumption of scientific knowledge (Collins, 2010). As a socio-structural factor, context plays a significant role in shaping science (Shapin, 2010). It can also influence the impact of network effects on scientific performance, given that context serves as the built environment where network actors are situated. Ynalvez and Shrum (2011) showed that context, as indicated by the place of graduate training, can significantly enable, constrain, and shape scientists' actions, behaviors, perspectives, and values to impact scientific performance in the form of journal productivity and intrinsic symbolic rewards such as recognition.

Social factors condition network effects on performance in science. A study on how social factors affect network effects can provide insights into the social mechanisms driving scientific productivity and recognition. That study can also help create models and tools that improve our understanding of science as a social activity and clarify how network effects interact with social factors (Fortunato et al., 2018).

Literature Review

Disciplines and areas of concentration organize contemporary science. It is structured around networks of scientists who are linked through conferences (virtual and in-person), publications, commentaries and reviews, and chats and casual conversations along college hallways, on-campus cafés, and cyberspace (Aguilar et al., 2013; Ehikhamenor, 2003; Ynalvez & Ynalvez, 2017). These linkages allude to a form of social structure in science (Shapin, 2008; Ynalvez, 2006) and can be conceptually cast and concretely described as a type of social network or scientific professional network (Fortunato et al., 2018; Shrum & Beggs, 1997; Ynalvez & Shrum, 2011).

In the digital age, social networks comprise an important socio-relational format. Its logic shapes performance in the processes of communication, experience, influence, consumption and production, and power (Castells, 2000; Teplitskiy et al., 2018). Network scholars contend that this emergent format is characterized by the priority of social interaction over social action (Ynalvez, 2006). Many scholars, such as Granovetter (1973), Otte and Rousseau (2002), and Fortunato et al. (2018), construed social networks as social structures in terms of sets of system members and sets of ties depicting exchanges.

In artificial intelligence and machine learning (Fortunato et al., 2018), networks are described as a countable set of actors with functions and relations defined by these actors (Scott, 2000; Wasserman & Faust, 1994). Networks are graphically depicted in n-dimensional space as sets of points representing actors and lines representing relations (Scott, 2000; Wasserman & Faust, 1994). Applied to science, points denote scientists, whereas lines denote communication lines, collaborations, co-authorships, mentoring relationships, or department/laboratory linkages. In Triple Helix science (Etzkowitz & Leydesdorff, 1995), social interactions and its web of social ties increasingly involve scientists that are dispersed globally, located in different time zones (Castells, 2000; Sklair, 2001), and participate in the various sectors of science such academia, government, and industry.

Studies have shown that social networks strongly shape the distribution of aid, assistance, information, resources, and support available to actors (McPherson & Smith-Lovin, 1987; Beggs et al., 1996; Beggs & Hurlbert, 1997; Hurlbert et al., 2000; Ynalvez & Aviles, 2021). In science, professional networks are associated with higher productivity levels in terms of publications in top journals, written monographs, grants awarded, and awards received (Ynalvez & Shrum, 2011; Hara et al., 2017). However, Teplitskiy et al. (2018) argued that professional networks can also infuse bias in reviewing, processing, and producing scientific knowledge. For example, instead of converging on the underlying quality of scientific work, reviewers (for journals, grants, or science awards) may disagree with one another and favor work from those within their professional networks (Teplitskiy et al., 2018). In a way, this threatens the norms of universalism and objectivity in science and can increase productivity and enhance the recognition of scientists with large, diverse, and well-positioned alters (Merton, 1968; Xie, 2014).

Social networks, in general, have several properties; these vary from one focal actor to another (Borgatti et al., 1998; Marsden, 1987; Otte & Rousseau, 2002; Shrum & Beggs, 1997; Ynalvez & Aviles, 2021). Two network properties are central to this present study: (a) range of compositional quantity and (b) range of compositional quality (Ynalvez & Aviles, 2021). Broadly, range indicates aspects of diversity in networks. It provides information about the concentration or spread of relational types without referencing any relational type (Shrum & Beggs, 1997). Metrics of the range are critical because networks with a greater range tend to reach deeply and extensively into social structure (Borgatti et al., 1998; Shrum & Beggs, 1997). In Triple Helix science, a greater range proves effective in tapping information and other kinds of resources (e.g., access to advanced instruments) necessary to produce quality science; it can also enhance the visibility and relevance of the research pursued (Schott, 1993).

Range can be either narrow or broad in compositional quantity by reaching few or many other actors (or alters), and in compositional quality by reaching only proximate or only distant alters, geography- and sector-wise (Borgatti et al., 1998; Schott, 1993). A natural metric of compositional quantity is network size. From an egocentric social network perspective, network size is the number of other non-redundant actors (or alters) that a focal actor (ego) is directly linked or connected to, weighted by tie strength (Borgatti et al., 1998; Otte & Rousseau, 2002). In the case of professional networks in science, for instance, network size may be a simple count of the number of other scientists with whom a focal scientist has direct and close contact. Larger networks represent greater diversity; better access to a large variety of capital, resources, support, and opportunities; and ready access to non-redundant, new or innovative information (Rogers, 1995; Shapin, 2008; Ynalvez & Aviles, 2021). For example, the greater the number of other scientists a focal scientist has, the higher the probability that one of these other scientists has the resources needed, such as funding opportunities, collaborative projects, academic job openings, or fellowship opportunities.

Geographical range is an example of compositional quality. For a focal scientist, the spatial range of their alters may be local, regional, national, or international. A scientist may have alters from the same scientific community, a scientific community in another part of the country, or scientific communities in developing (e.g., Sub-Saharan Africa) and developed areas (e.g., Western Europe). As a metric, geographical range is an important indicator of participation in international science (Castells, 2000; Schott, 1993). Sectoral range is another aspect of compositional quality relevant in the Triple Helix science era. The sectoral range for a scientist may span universities (or academic sector), firms (or commercial sector), and national laboratories (or government sector). At present, there is an increasing trend for scientific activities, engagements, and collaborations to involve more than one sector. There is also a growing number of studies that focus on the negative impact (e.g., academics being secretive about their data and results) and the positive impact (e.g., funds for academic lab equipment and supplies) of academic–commercial science linkages.

As a community, scientists are evaluated based on their productivity and recognition. Productivity is measured by the number of manuscripts written, data sets generated, inventions patented, peer-reviewed journal articles published, monographs produced, books published, and conference presentations given (Aguilar et al., 2013; Keith et al., 2002; Hara et al., 2017). Among these, publishing peer-reviewed articles is a key indicator of personal merit, currency in one's field, and novel work. Therefore, journal productivity is one of the most significant measures of scientific productivity (Hara et al., 2017; Ynalvez & Shrum, 2011). Indeed, science disseminates knowledge mainly through writing (Ynalvez & Ynalvez, 2017). Without written output, scientific knowledge production would be unproductive and incomplete (Callon, 1995). Many studies have examined the factors that influence journal productivity such as age (Levin & Stephan, 1991), gender (Fox, 2005; Leahey, 2006; Xie & Shauman, 1998), nationality and citizenship (Bozeman & Corley, 2004), internet utilization (Vasileiadou & Vliegenthart, 2009; Ynalvez et al., 2005), and international network ties (Hara et al., 2017). However, only a few studies have explored the moderating role of professional status and sociocultural context in clarifying the link between professional networks and journal productivity.

Scientific performance is also indicated by the collective recognition by the scientific community and the public about the impact, importance, quality, and value of a scientist's work. Recognition is typically expressed through the bestowing of non-material awards and extrinsic rewards such as medals, decorations, orders, and prizes (Frey, 2007; Ynalvez & Shrum, 2011). Science has an elaborate and extensive system of awards. For example, universities confer titles such as honorary doctorates; professional associations and governments award medals such as the Fields Medal in mathematics, Priestley Medal in chemistry, the U.S. National Medal of Science, and the Nobel Prizes for science and literature; prestigious fellowships are awarded in academies of science (e.g., Fellow of the Royal Society; Fellow of the American Association for the Advancement of Science), and there are also the best paper awards given at annual meetings and conferences. Awards have a vital signaling function because they indicate what kind of behavior, character, and output is desired and valued within a scientific discipline or the general scientific community beyond the typical performance of duties and responsibilities (Frey, 2007). As a mechanism for status attainment in science, receiving awards enhances career opportunities, shapes career trajectories, and signals superior talent and motivation to those inside and outside the discipline or the community (Frey, 2007; Lincoln et al., 2012).

Factors influencing performance (productivity via publications, recognition via awards) include access to both material resources such as equipment and instruments, lab spaces and supplies, and funding, and non-material resources such as quality graduate students, mentors, productive collaborations, and solid and resource-endowed professional networks (Wigren-Kristoferson et al., 2011; Benavides & Ynalvez, 2018; Ynalvez & Shrum, 2011). The Matthew effect in science (Xie, 2014) and the Matilda effect in science (Lincoln et al., 2012) each speaks to the cumulative advantage that accrues to scientists who are already well-positioned (e.g., in high status from prestigious institutions) even if less-positioned scientists have equally contributed to scientific work. Understanding the influence of academic rank and sociocultural context (institutional or geographical) on the relationship between professional network properties (geographic and sectoral range) and scientific performance can help us understand the mechanisms involved in the social process of science. Wide-range networks benefit scientists with more resources, support, and visibility. However, having a high academic rank and being located in a reputable and resource-rich place can further amplify productivity and recognition. This aligns with the Matthew effect and the Matilda effect in science.

Theoretical Model

The theoretical model that guides this study is presented in Figure 1. Applied to scientific life, the model engages concepts germane to social networks, such as network size (Ynalvez & Shrum, 2011), geographical range (Castells, 2000; Schott,1993), sectoral range (Etzkowitz & Leydesdorff, 1995), sociocultural context (Collins, 2010; Gieryn, 1995; Shapin, 2010), social status (Xie, 2014), and performance as indicated by publication productivity (Hara et al., 2017) and awards (Lincoln et al., 2012). Implicit to this model is the assertion that context of and status in science jointly configure how aspects of scientific professional networks influence scientific performance. That influence translates to advantages, disadvantages, disparities, and inequalities in science. That said, this present study assists in understanding how networks shape performance and inequalities and how the effects of networks are, in turn, conditioned by social factors pertaining to status and context. This study applies these concepts to science, scientists, and scientific activities. As a social institution, science is typically seen as operating within the scope of what is construed as meritocratic, objective, and rational (Callon, 1995; Sismondo, 2010).

In applying this theoretical model, the role of professional networks in scientific life is not privileged; instead, a symmetrical stance is taken. This stance challenges the thinking that the impact of professional networks on scientific performance is necessarily advantageous and beneficial to academic scientists regardless of status or context. This same stance leads to this study's hypotheses that the impact of professional networks on scientific performance

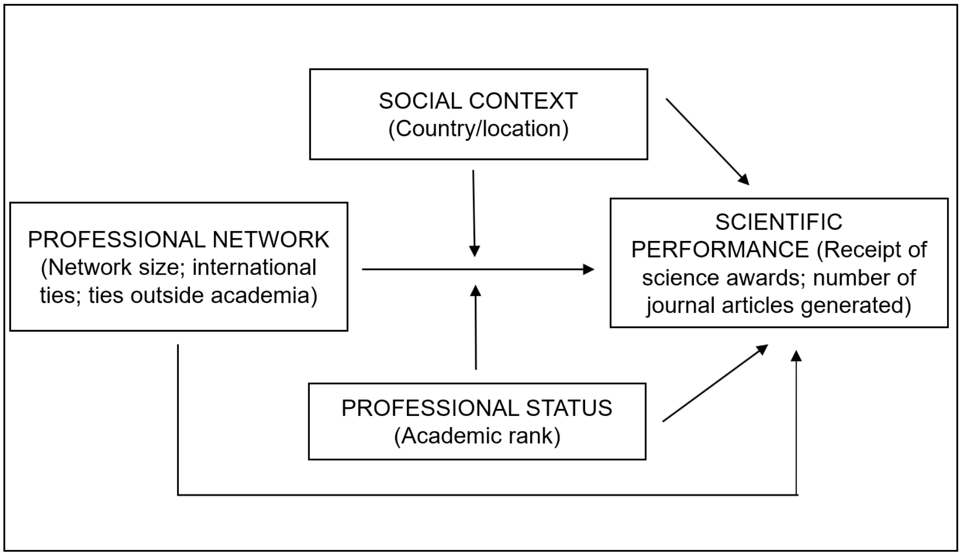

Figure 1. Theoretical Model

comprises (a) main effects, (b) conditional effects whereby academic rank configures the influence of networks, and (c) conditional effects whereby sociocultural setting configures the influence of networks; and that, the more crucial and salient effects are in the form of conditional effects.

Methods

Data Collection Method and Sample

Data for this study come from an original face-to-face quantitative survey of 105 chemical science professors in elite research universities in Japan, Singapore, and Taiwan. Focusing on chemical sciences is justified for the following reasons: Firstly, it is a well-established scientific field with comparable levels of competencies, development, and organization across the different study locations. Secondly, it has a long-standing history of collaboration and professional networking among the three sectors of science—academia, industry, and government, domestically and internationally, as evidenced by Calvert and Patel (2003). Regarding the scientific profile, a contextual description of these three locations is published in Ynalvez and Aviles (2021) and Aguilar et al. (2013). These survey interviews were conducted at the offices or laboratories of respondents from June to August 2013. Institutional Review Board approval was secured and obtained before conducting research activities (IRB-2008-06-22; approved 4/7/2009).

As a quantitative research approach, face-to-face data collection is highly accurate and reliable compared to other methods, such as online or internet-based surveys (Kerlinger & Lee, 2000). Face-to-face survey allows for deeper probing and firsthand observation of the study location and the target population. However, face-to-face interviews that last anywhere from 60 to 120 minutes and require interviewers to travel internationally are immediately expensive, given the costs of air travel, accommodations, meals, incentives for respondents, among other things. Even with a research grant to fund this study, the logistical scenario and resultant budgetary constraints presented by a face-to-face survey in various locations abroad limited the study's sample size. Although only afforded access to a small sample by budgetary constraints, my research team members did their best to obtain a sample that was as representative as possible by obtaining random samples of professors within each country. The online faculty directories of the selected universities were used as sampling frames.

Outcome Variables

Two survey items were used to measure scientific performance:

1. Number of peer-reviewed journal articles with an impact factor of at least 4.0 published in the two years before the survey (Bhagwatwar et al., 2013; Hara et al., 2017; Ynalvez & Shrum, 2011). The reliability of these measures is high as respondents were asked to enumerate the journals and report the number of articles published in each of those journals (Kerlinger & Lee, 2000). Adding to the reliability of responses was the fact that both respondents and interviewers signed informed consent forms.

2. Receipt of any science awards two years before the survey (Ynalvez, 2006). Response to this item was either a "yes" (coded 1) or a "no" (coded 0).

Predictor Variables

The study used two main predictors to analyze the professional networks of scientists. The first predictor was whether they had international contacts, coded as 0 for "no" and 1 for "yes." The second predictor was whether they had contacts outside the academic sector, coded as 0 for "no" and 1 for "yes." The concept of international connections was influenced by research conducted by Hara et al. (2017) and Ynalvez and Shrum (2011), who examined what factors determine the development of relationships between faculty and graduate students across borders and how these connections can impact academic productivity in three East Asian countries. Gray's (2011) study, along with the studies above, inspired the creation of a metric in this study to determine the presence or absence of non-academic connections.

Moderator Variables

Two survey items served as moderators, one representing professional status and the other social context. Inspired by Benavides and Ynalvez (2018) in their study of scientific ambidexterity among academics of various ranks, response categories for this status were assistant, associate, and full professor. This item was transformed into two dummy variables for regression analysis, with the assistant professor serving as the reference category. Social context was indicated by a survey item related to the respondents' location, which had the following categories: Japan, Singapore, and Taiwan (Bhagwatwar et al., 2013). This item was similarly transformed into two dummy variables, with Taiwan being the reference category (Hara et al., 2017; Benavides & Ynalvez, 2018; Ynalvez & Aviles, 2021).

Control Variables

The number of hours in a typical week allocated to teaching and the number of professional scientists supervised served as control variables in our regression models. Professional scientists included those classified as postdoctoral fellows, research professors, and visiting scientists/scholars. Network size (range: 0-10 alters) was derived from a name-generator that solicited "names" (not the names to safeguard privacy) of a maximum of 10 individuals (or alters) with whom a respondent consulted, discussed, and shared important research matters with (Marsden, 1987). In addition, a name-interpreter solicited information about each alters' geographical location, science sector, relationship to the respondent, frequency of interaction with the respondent, and so forth (Hurlbert et al., 2000; Hurlbert et al., 2001).

Analytical Techniques

In consideration of the levels of measurement, empirical distributions of the outcome variables (i.e., receipt of awards, number of journal articles), and effective sample size, a binary logistic regression approach was used to model the receipt of science awards. In contrast, a negative binomial regression approach was used to model the number of journal articles. Robust standard errors were used in testing the statistical significance of regression estimates (Ynalvez et al., 2012), and 5%, 1%, and 0.1% type-I error rates were used in identifying statistically significant estimates. IBM's Statistical Packages for the Social Sciences 28 Premium Version's generalized linear model procedure was used to conduct these analyses.

Results

Descriptive Statistics

As mentioned, data were collected from an original face-to-face survey of 105 chemical science professors at elite research universities in Japan, Singapore, and Taiwan. Descriptive statistics for all the variables in this study are presented in Table 1. The mean number of journal publications produced by respondents within the two years before the survey was 9.8, with a standard deviation of 8.4. The lowest number of publications reported was 1, and the highest was 65 (Note: not a mistake). Consistent with the literature on publication productivity, this measure of scientific outcome is positively skewed. Regarding receipt of science awards, 32.0% were award recipients within the two years before the survey; most scientists did not receive any scientific award within that period.

In terms of social context, 35 (33.3%) respondents were based in Japan, another 35 (33.3%) in Singapore, and yet another 35 (33.3%) in Taiwan. This distribution of respondents was much a function of budgetary constraints, given the international nature of the study and the goal of keeping representation equal among the three locations. With regard to academic rank, 45 (43.3%) respondents were full professors, 33 (31.7%) were associate professors, and 26 (25%) were assistant professors. The mean number of hours teaching per week was 11.6 hours, with a standard deviation of 11.6 hours. The minimum and the maximum number of hours teaching per week were 0 and 90, respectively. The average number of scientists supervised by respondents was 1.6, with a minimum and a maximum of 0 and 5, respectively.

The average professional network size was 4.8, with the smallest at 0 and the largest at 10. Note that the name-generator used was capped at soliciting information about 10 alters that constituted a close-knit set of research confidants (Note: To reinforce and elaborate on the notion of research confidants, interviewers asked respondents to think of people with whom they (respondents) were comfortable discussing details of their research without fear or hesitation that their techniques, ideas, or results might be scooped or stolen). In terms of network social context, 48.6% of professors had international ties. This estimate is surprisingly low given the affordability and ease of international travel to conferences and meetings as well as the availability of ready access to internet-based communication in the years prior and during the survey (Note: This description and mindset about international travel are contextualized in a time and situation prior to the COVID-19 pandemic). But again, compared to Western developed countries (e.g., Canada, the United States, and the United Kingdom), the countries we visited were much more scientifically insular and inward-looking (Aguilar et al., 2013; Kurokawa, 2008).

As for network sectoral composition, 31.4% of professors had ties outside academia (i.e., corporate and government). In the age of Triple Helix science described by Etzkowitz and Leydesdorff (1995), this percentage is unexpectedly low. It may be that cross-sectoral scientific collaborations (Gray, 2011) are far more practiced in Western developed countries than in the developed non-West. Further examination of the data via cross-tabulation of these two network compositional aspects revealed that about a quarter (24.8%) of respondents have international ties in the non-academic sector, thus exhibiting both geographical and sectoral range. Indeed, even with the globalization of science, the rapid rise of digital technologies, and the emergence of Triple Helix science, a plurality of respondents (44.8%) still had neither international ties nor ties in the non-academic sector. This is not to say that these scientists were isolated; instead, this is to say that they did not have contacts in realms that are construed to be important in globalizing Triple Helix science. Such an observation may again be explained by Kurokawa (2008), who observed that science in the developed non-West is still very insular and inward-looking, which can be interpreted broadly as being more confined and focused within the academic sector and the local.

Regression Results

To explore how the geographical and the sectoral composition of professional networks associate with scientific performance (i.e., number of journal articles generated and receipt of science awards), the taxonomy of models' approach to regression modeling was performed (Singer & Willet, 2003). This approach to model building starts with a baseline model (M1) where independent variables comprise control and professional network variables. This is followed by model 2 (M2), whereby status and context are added to M1. This is again followed by model 3 (M3), whereby interaction terms between network composition, status, and context are added to M2. M3 is the full model with M1 nested within M2, and M2 nested within M3. M1 and M2 are also referred to as reduced models.

The taxonomy of models for the number of journal articles generated is in the form of negative binomial regression models, whereas that for receipt of science

Table 1

Descriptive Statistics

	N	Mean	Median	SD	Min	Max
Japan (1=yes)[a]	105	0.33	–	–	0	1
Singapore (1=yes)[a]	105	0.33	–	–	0	1
Full Professor (1=yes)[b]	104	0.43	–	–	0	1
Associate Professor (1=yes)[b]	104	0.32	–	–	0	1
Hours teaching per week (0–168)	104	11.58	10.00	11.58	0	90
No. of scientists supervised	104	1.65	1.00	1.76	0	5
Network size (0–10)[c]	105	4.78	4.00	2.73	0	10
Has international alters (1=yes)	105	0.49	–	–	0	1
Has non-academic alters (1=yes)	105	0.31	–	–	0	1
No. of articles produced[d,e]	100	9.84	8.00	8.43	1	65
Has received a science award (1=yes)[d]	100	0.32	–	–	0	1

Note: a = Taiwan is reference category. b = Assistant professor is reference category. c = name-generator capped at 10 alters. d = in the last two years of survey year. e = the maximum number reported, 65, is not a mistake and has been verified.

Table 2

Binary Logistic Regression Results for Receipt of Science Awards

Predictors	M1			M2			M3		
	B	SE	p-value	B	SE	p-value	B	SE	p-value
Intercept	-1.507	0.5326	0.0047**	-2.173	1.0218	0.0335*	-1.831	1.4953	0.2207
I. *Cultural Content*									
Japan	–	–	–	1.447	0.6569	0.0276*	3.693	1.3509	0.0063**
Singapore	–	–	–	0.464	1.0650	0.6629	1.509	1.5651	0.3351
II. *Professional Status*									
Full professor (Full)	–	–	–	0.399	0.8782	0.6497	-1.335	1.1818	0.2585
Associate professor (Assoc)	–	–	–	0.122	0.7064	0.8628	-1.560	1.0122	0.1232
III. *Controls*									
Hours teaching in a week	0.016	0.0192	0.4098	0.007	0.0196	0.7093	0.005	0.0221	0.8382
No. of scientists supervised	0.251	0.1190	0.0350*	0.245	0.1461	0.0933	0.239	0.1727	0.1656
IV. *Professional Networks*									
Network size	0.046	0.0713	0.5210	-0.019	0.1037	0.8535	-0.121	0.1317	0.3602
Has international alters (HIA)	0.147	0.4668	0.7524	0.497	0.6879	0.4699	-2.021	2.1478	0.3468
Has non-academic alters (HNA)	-0.413	0.5200	0.4276	-0.532	0.5843	0.3627	2.377	2.4298	0.3280
V. *Interaction Effects*									
Full X HIA	–	–	–	–	–	–	5.910	2.1659	0.0064**
Assoc X HIA	–	–	–	–	–	–	2.827	1.5736	0.0724
Japan X HIA	–	–	–	–	–	–	-4.376	1.8112	0.0157*
Singapore X HIA	–	–	–	–	–	–	1.364	1.9399	0.4820
Full X HNA	–	–	–	–	–	–	-2.492	2.3341	0.2856
Assoc X HNA	–	–	–	–	–	–	-0.651	1.9390	0.7371
Japan X HNA	–	–	–	–	–	–	0.237	1.6878	0.8885
Singapore X HNA	–	–	–	–	–	–	-3.663	1.9213	0.0565
	Value	**df**	**Value/df**	**Value**	**df**	**Value/df**	**Value**	**df**	**Value/df**
Deviance	118.838	95	1.251	114.365	92	1.243	97.010	84	1.155
Difference Relative to the Full Model	21.828	12	*	17.356	8	*	–	–	

Note: *, ** denote significance at the .05 and .01 level, respectively.

awards is in the form of binary logistic regression models. In determining the best regression model (i.e., M3 for both measures of scientific performance), deviance statistics were only one of several criteria considered. Other criteria applied were (a) the model's alignment with the theoretical literature, (b) the author's knowledge of the study population, and (c) the research team's frontline knowledge of the study locations. To solely base the determination of the best regression model on deviance statistics makes the determination void of theoretical and experiential knowledge of the topic, study locations, and target population.

Receipt of Science Awards

It is clear from Table 2's M1 results that none of the network variables are significantly associated with the receipt of science awards. These results reveal that network effects do not manifest as main effects on scientific recognition. Here: The terms *main effects* and *interaction effects* are used in a statistical sense. Using these terms does not mean nor convey the idea of strict cause-and-effect between the independent and the dependent variables, which is not logical and reasonable given that data for this study were collected via surveys and not through randomized controlled experiments. To better show what is meant by the terms main effect and interaction effect, consider the regression equation: $Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_1{*}X_2 + \varepsilon$. In this equation, β_1 and β_2 are coefficients pertaining to the main effects of X_1 and X_2 on Y, respectively. At the same time, β_3 relates to the interaction effect of X_1 and X_2 on Y. Interaction effect means that the impact of X_1 on Y is conditioned by X_2, and vice versa.

The addition of professional status and social context (Table 2, M2) does not change the nonpredictive power of network variables on receipt of science awards. However, the addition of interaction terms (Table 2, M3; academic rank X having international ties, and location X having international ties) reveals the conditional nature of network effects on the receipt of science awards and the significant main effect of social context.

The significant main effect of context means that there are significant differences among scientists in Japan, Singapore, and Taiwan with respect to the probability of receiving science awards. Professors in Japan (*B*=3.69, *p*=.006) are more likely to receive awards than their counterparts in Singapore (*B*=1.51, *p*=.335) and Taiwan (reference category). No main effect is observed for professional status or any of the professional network variables. Again, although network variables do not manifest as main effects on receipt of science awards, they manifest as interaction effects with professional status (see Figure 2) and social context (see Figure 3). In other words, the predictive power of having international ties on the probability of receiving a science award is conditional and dependent on academic rank and social context.

In specific terms, it is clear from Figure 2 that having international ties is associated with the receipt of science awards for full professors, the highest academic rank. No such advantage from having international ties was observed for associate professors and assistant professors. These results suggest that having international professional ties is not uniformly advantageous across statuses or academic ranks. The benefits of having international ties appear synergistic with professors with the highest status or academic rank (i.e., the full professor), but not quite so for lower academic ranks such as associate and assistant professor. This is consistent and corroborates the Matthew effect in science (Merton, 1968; Sismondo, 2010; Xie, 2014).

Shifting attention to Figure 3 shows another interaction effect at play whereby scientists in Taiwan who reported having international ties were associated with significantly higher occurrences of receiving awards compared to those who did not have international alters. No such advantage was noted for professors with international ties in Japan or Singapore. These results suggest that having international ties is also not uniformly advantageous across social contexts. Reflecting on my firsthand research experience in the scientific systems in these three social contexts, it appears that the benefit of having international ties is synergistic in a social context that can be described as being at the middle ground of being close and open, formal, and informal, and conservative and liberal (in this case, Taiwan). This same synergistic effect appears muted in social contexts that are either close, formal, insular, and conservative (in this case, Japan) OR those that are open, informal, and liberal (in this case, Singapore; Aguilar et al., 2013; Ynalvez & Aviles, 2021).

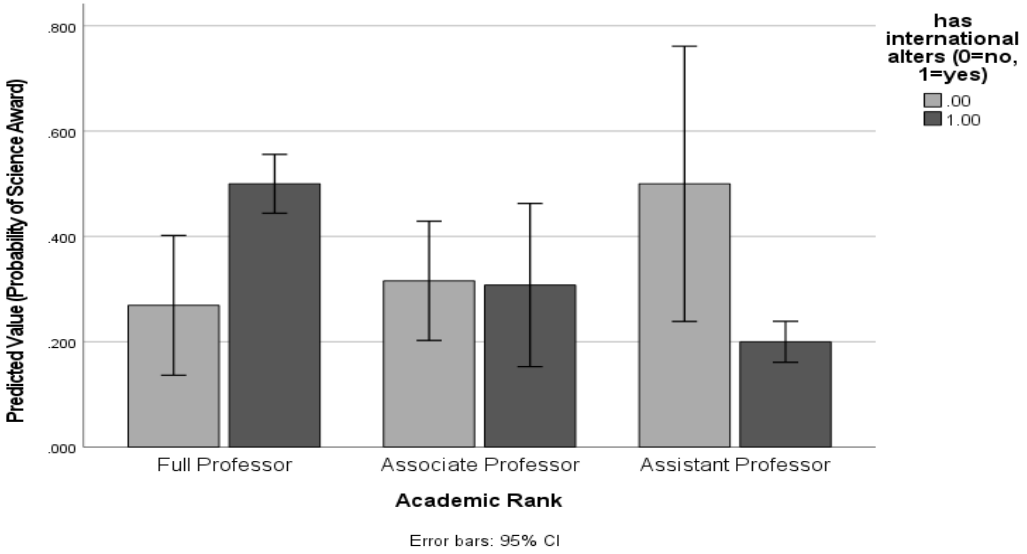

Figure 2. Graph Showing the Conditioning Effect of Academic Rank on Having International Alters With Respect to Receipt of Science Awards

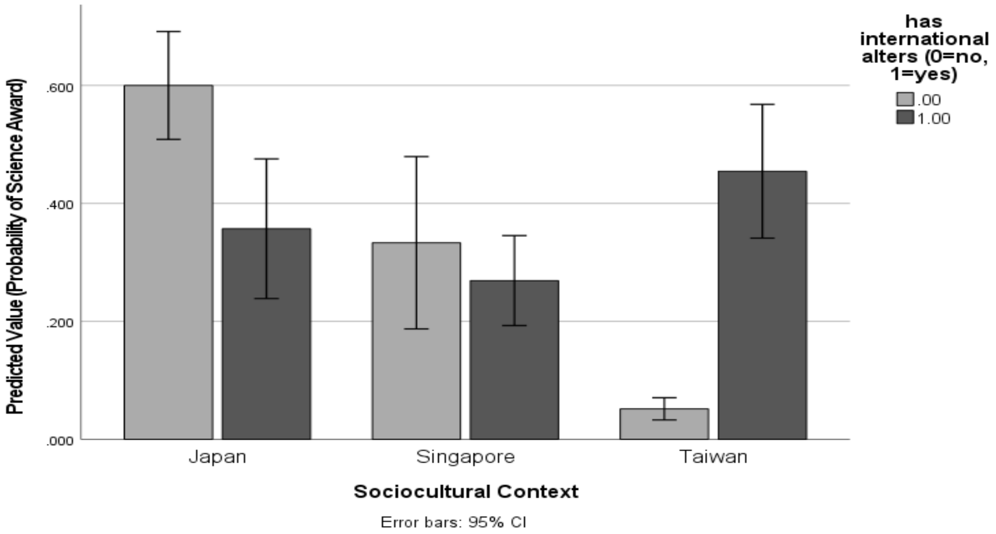

Figure 3. Graph Showing the Conditioning Effect of Social Context on Having International Alters With Respect to Receipt of Science Awards

In summary, the results in Table 2 underscore the following observations about network effects on scientific recognition:

1. Network effects take the form of interaction effects and not main effects. This is to say that network effects are conditional and contingent in nature.
2. Network effects are conditioned by professional status. This means that a status considered a master status within a particular context conditions network effects. This observation has implications for and betters our understanding of the Matthew effect in science (Merton, 1968; Sismondo, 2010; Xie, 2014).
3. Network effects are conditioned by social context, which betters our understanding of the social shaping of science in geographical

locations such as the developed non-West (Shapin, 2010).
4. Although network effects exist, they appear to be very much conditioned by micro- and macro-level social factors. This observation supports the assertion of DiMaggio and Garip (2012) in terms of the nature of network effects.

Together, these observations help develop novel and non-ad hoc hypotheses about the nature of network effects and their role in scientific performance, stratification, and inequality in scientific life (Xie, 2014).

Articles Published

Table 3 shows the taxonomy of models for the number of journal articles published within the two years before the survey. Dispersion parameters for the negative binomial regression models are not estimated but are fix at 1. M1 shows that none of the network variables are associated with publication productivity. Adding status and context as predictors does not result in any of the network variables being significant (M2); however, both status and context are significant predictors. In statistical parlance, both status and context exhibit main effects. Results from Table 3 M3 reveal significant effect of context (Japan: *B*=0.44, *p*=0.120; Singapore: *B*=0.97, *p*=0.000) and status (Full Prof: *B*=1.07, *p*=0.002; Assoc Prof: *B*=0.48, *p*=.079).

As in the case of receipt of awards, professional network variables (Network size: *B*=0.044, *p*=0.0620; Has international alters: *B*=0.354, *p*=0.449; Has alters in non-academic sectors: *B*=0.456; *p*=0.382) exhibit no main effects on the number of journal articles produced (Note: Although the residual-deviance tests for M1 versus M3, and M2 versus M3 turned out not to be significant, the results of M3 are consistent with theory and what the author knows about the realities in the scientific systems visited and observed). Although no main effects were observed with respect to the compositional aspects of networks, interaction effects with social context and professional status were observed. Specifically, social context had an interaction effect with having international alters (Japan X Has international alters: *B*=-1.19, *p*=0.000; Singapore X Has international alters: *B*=-0.86, *p*=0.022;), whereas professional status had an interaction effect with having alters in non-academic sectors (Full Prof X Has alters in non-academic sectors: *B*=-0.564, *p*=0.310; Assoc Prof: *B*=-1.00, *p*=0.034).

To be more precise, having international alters seems to have benefited professors in Taiwan over professors in Japan and Singapore in terms of the number of journal articles generated. Furthermore, having alters in non-academic sectors appears to have benefited both assistant and full but not associate professors. Said another way, having ties abroad and in non-academic sectors interacts with status and social settings. These effects are graphically shown in Figures 4 and 5. A closer look at Figure 4 reveals that among scientists in Japan, those with international ties reported significantly lower journal productivity.

In contrast, among scientists in Taiwan, those with international ties reported significantly higher journal productivity. These results suggest that international professional ties do not have uniform or monotonically advantageous impacts across social contexts. In like manner, a closer examination of Figure 5 shows that among associate professors, those with ties outside academia reported lower article productivity. There were no such observed differences between assistant professors and between full professors. These results suggest that having professional ties outside academia has no detectable benefits in terms of journal productivity; it even appears significantly disadvantageous for professors at mid-ranking academics, such as associate professors.

What is curious and deserves explanation is the following set of results: (a) the size of scientists' professional network does not impact journal productivity; (b) aspects of professional networks themselves do not impact (or have no main effect on) productivity; instead, their impacts are expressed as interaction effects with professional status and social context, or are conditioned by professional status and social context; and (c) between having international ties and ties in non-academic sectors, the former is stronger than the latter in terms of impacting productivity. When it comes to productivity and recognition in science, the geographical range of a network and its interaction with rank and social setting play a significant role. However, the impact of these interacting factors on productivity and recognition is unpredictable, which leads me to rethink the Matthew effect as a theorem to explain inequality in scientific life.

Table 3

Negative Binomial Regression Results for Number of Journal Articles Generated

Predictors	M1			M2			M3		
	B	SE	p-value	B	SE	p-value	B	SE	p-value
Intercept	2.265	0.1606	0.0000**	1.445	0.2323	0.0000**	1.297	0.3392	0.0001**
I. *Cultural Content*									
Japan	–	–	–	-0.006	0.1980	0.9768	0.441	0.2839	0.1199
Singapore	–	–	–	0.534	0.2081	0.0103*	0.975	0.2670	0.0003**
II. *Professional Status*									
Full professor (Full)	–	–	–	1.064	0.2237	0.0000**	1.075	0.3545	0.0024**
Associate professor (Assoc)	–	–	–	0.619	0.1615	0.0001**	0.485	0.2762	0.0792
III. *Controls*									
Hours teaching in a week	-0.004	0.0038	0.2448	-0.006	0.0046	0.1658	-0.007	0.0035	0.0480*
No. of scientists supervised	0.145	0.0337	0.0000**	0.134	0.0331	0.0001**	0.099	0.0320	0.0020**
IV. *Professional Networks*									
Network size	-0.028	0.0198	0.1522	-0.042	0.0214	0.0524	-0.044	0.0233	0.0622
Has international alters (HIA)	-0.117	0.1559	0.4544	0.041	0.1371	0.7656	0.354	0.4679	0.4492
Has non-academic alters (HNA)	-0.055	0.1751	0.7535	-0.034	0.1445	0.8147	0.456	0.5218	0.3818
V. *Interaction Effects*									
Full X HIA	–	–	–	–	–	–	0.196	0.4383	0.6552
Assoc X HIA	–	–	–	–	–	–	0.634	0.3437	0.0652
Japan X HIA	–	–	–	–	–	–	-1.193	0.3198	0.0002**
Singapore X HIA	–	–	–	–	–	–	-0.860	0.3749	0.0218*
Full X HNA	–	–	–	–	–	–	-0.564	0.5555	0.3096
Assoc X HNA	–	–	–	–	–	–	-1.005	0.4732	0.0337*
Japan X HNA	–	–	–	–	–	–	0.206	0.2865	0.4728
Singapore X HNA	–	–	–	–	–	–	-0.121	0.5298	0.8192
	Value	**df**	**Value/df**	**Value**	**df**	**Value/df**	**Value**	**df**	**Value/df**
Deviance	38.017	93	0.409	31.495	88	0.358	25.771	80	0.322
Difference Relative to the Full Model	12.246	12	ns	5.723	8	ns			

Note: *, ** denote significance at the .05, 0.1, and .001 level, respectively.

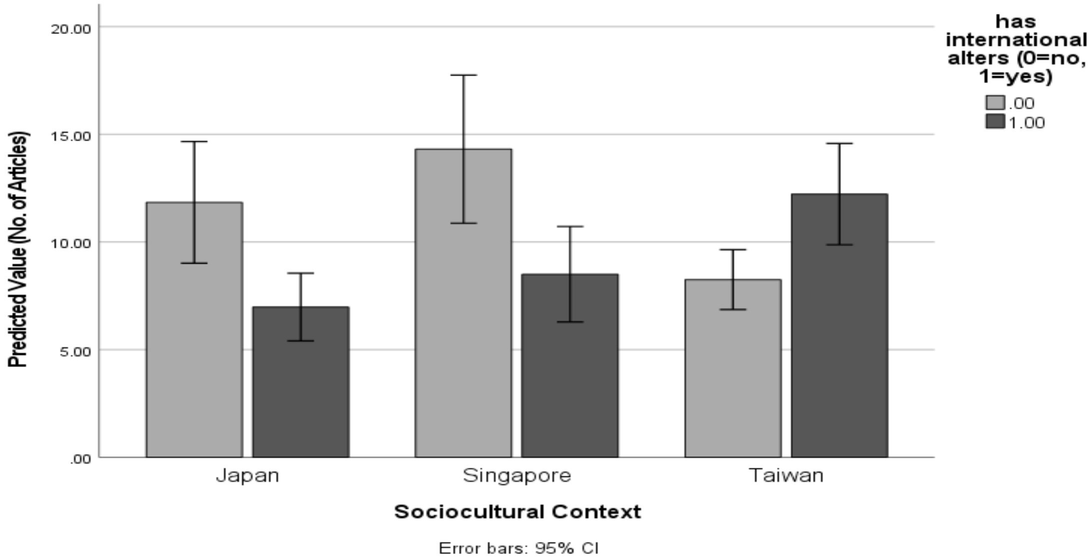

Figure 4. Graph Showing the Conditioning Effect of Social Context on Having International Alters With Respect to the Number of Articles Published

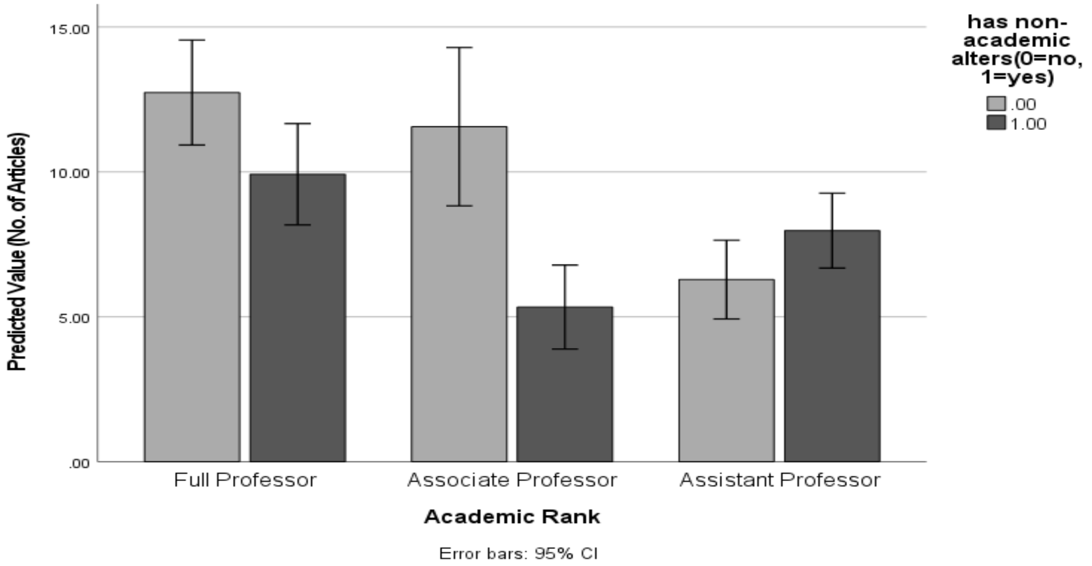

Figure 5. Graph Showing the Conditioning Effect of Academic Rank on Having Non-Academic Alters With Respect to the Number of Articles Published

Discussion

Undeniably, professional status, social context, and professional networks are critical factors in understanding social inequality in science and scientific systems, more so as these relate to performance, productivity, and recognition. Professional status in science or position in the social structure of science and scientific systems specifies who counts or does not count as a scientist. It also specifies who has authority, influence, prestige, and privilege, as well as who has access to material (e.g., computational, monetary, lab, instrument, equipment, etc.) and human resources (e.g., postdoctoral fellows, research assistants, technicians, consultants, etc.) (Ynalvez & Shrum, 2011). In science, professional status in the form of academic rank is a master's status. Professional status has been linked to the Matthew effect in science and is salient in the various conversations on discrimination, privilege, and inequality in science that have to do with gender, nationality, rank, ethnoracial identity, or even place of graduate education (Merton, 1968; Sismondo, 2010; Xie, 2014). Social context, as an arena for scientific work and social inequality, prescribes what counts and does not count as important, prioritized, and valued. It also legitimizes which status has authority, influence, prestige, privilege, and power. For example, Ynalvez and Shrum (2009) have shown that the place of graduate education impacts the prestige and respect professors receive from colleagues. Within Philippine scientific research systems, doctoral degrees obtained abroad carry more prestige than those obtained locally, and among doctoral degrees earned abroad, those from U.S. doctoral training systems carry the highest prestige. On the other hand, professional networks and their effects have also been key to understanding and explaining scientific productivity where network properties such as composition, range, and size have been linked to advantages and inequality in productivity and visibility.

This study's results highlight the impact of professional status and professional networks on the receipt of science awards and journal productivity. Specifically, the impact of status (as indicated by academic rank) on scientific performance was expressed in the form of regression model main effects and interaction effects. In contrast, the impact of networks (as indicated by having international alters and by having alters in non-academic sectors) only takes the form of interaction effects. In a way, the impact of status has both an independent and unconditional (main effect) and a conditional (interaction effect) component, while the impact of networks appears to be predominantly conditional in nature. This observation is evident from the independent and robust impact of status and its capacity to condition and shape network effect: status conditions how networks impact receipt of awards and journal publication productivity. In the era of global and Triple Helix science, one would think that network effects such as those that derive from having international alters and from having non-academic alters would take the form of main effects; however, the results of this study indicate that this is not the case. Status and social context still impact scientific performance more than social relationships. In conditioning network effects, status may have the capacity to determine the identities and attributes of alters and the types of relationships that develop. On the other hand, social context may have the capacity to determine how alters and types of relationships are able to provide support.

In retrospect, two compositional aspects of scientific professional networks made salient by the globalization of science, digital technologies, social media, and Triple Helix science were examined: (a) having international ties and (b) having ties outside the academic sector. Both compositional network aspects did not exhibit any independent and unconditional influence (i.e., main effects) on two scientific performance measures: journal publication and receipt of science award. Instead, the impact of having international ties on performance in science was conditioned by the larger social context (e.g., Japanese scientific culture). In contrast, the impact of having ties outside academia was conditioned by professional status (i.e., academic rank). Having international ties appeared advantageous in social contexts that were neither conservative nor liberal, as exemplified by Taiwan. In seemingly conservative scientific systems such as those in Japan, having international ties was not particularly advantageous in enhancing performance and recognition in science. The same can be said for seemingly more liberal scientific systems like those we visited in Singapore. Having international professional ties in systems that were either open or close are interpreted in such a manner that in open systems, having international ties was seen as commonplace and mundane, hence taken for granted. In the case of a close system, having international professional ties was not valued, or maybe not as valued as local ties. These results indicate the finer variations among scientific research systems within the dichotomies of scientific systems in the West and the non-West.

Conclusion

An insightful idea in sociology is that social entities—whether individual, organizational, or societal level—are situated within webs of social interactions and relationships referred to as social networks (Borgatti et al., 2009). This insight can explain social phenomena such as creativity, finding a job, accessing critical and novel information, corporate profitability, and so forth (Borgatti et al., 2009; Granovetter, 1973). Focused on scientists in research universities in three developed non-Western countries (Japan, Singapore, Taiwan), this study explored the impact of scientists' professional networks on scientific performance: journal productivity and receipt of science awards. Specifically, the interplay between professional networks (social relationships), on the one hand, and scientists' professional status (position in social structure) and social context, on the other hand, was explored. This exploration was triggered by the observation that extant literature is heavy on professional networks' universal positive impact, with that impact being unconditional on other social factors. Indeed, the extant literature highlights the preeminence of networks in social analysis.

Examining the main effect of professional networks (Hara et al., 2017; Hong & Zhao, 2016; Ynalvez & Shrum, 2011) helps understand how networks directly, independently, and unconditionally impact scientific performance. However, examining their interaction effect, as exemplified and carried out in this study, advances knowledge on how micro- (i.e., academic rank) and meso-level (i.e., social context) bases of inequality in science can either strengthen, weaken, or suppress network effects on scientific performance (Merton, 1968; Xie & Shauman, 1998). This study focused on professional network effects that derive from two compositional aspects: (a) having international ties and (b) having ties in non-academic sectors. The importance of these aspects to scientific work derives from the heightened global social interaction among scientists and the increased collaborations of academic scientists with counterparts in government and industry because of market-focused national innovations policies (Gray, 2011) and the rise of academic capitalism (Slaughter & Rhoades, 2004), which encourages academic scientists to engage in research that has direct applications to spur economic growth.

This study provides preliminary evidence that professional network effects are not universally advantageous across social statuses and social contexts. Some statuses and contexts work synergistically with network effects to improve performance, but some do not. This paper provides insights into how professional networks may either work toward ameliorating, exacerbating, or muting existing disparities and inequalities in scientific research systems in terms of their differential impact on scientific performance across academic ranks and organizational settings. Applied to scientific life, the results of this study highlight the unpredictability of network effects on the productivity and recognition of scientists. That unpredictability stems from network properties' interaction with scientists' rank and the social setting in which they are embedded. In a way, these results challenge us to rethink the dynamics of inequality in science and the applicability of the Matthew effect. That said, and with more studies replicating this study, research administrators may need to consider how professional networks might impact research creativity, productivity, and discovery, as well as the attribution of recognition in science. That way, research administrators may be able to develop strategies and pursue initiatives that moderate and optimize network effects on scientific performance.

Although insightful, the results of this present study remain preliminary. At best, these results translate into a guide to generate novel and fine-tuned hypotheses that can be evaluated and verified using large representative samples with more diverse social contexts and scientific disciplines. Limitations are derived from (a) a small sample size along with an even smaller collection of social contexts, which not only limits statistical power but also limits the number of controls in the regression models, and (b) a purely quantitative approach that limits nuanced, deeper, and emic-oriented insights about the challenges and situations of respondents. Future studies are encouraged to apply both quantitative and qualitative data collection methods for a better and more comprehensive understanding of scientific performance as it relates to the interaction of social networks on the one hand and social status and social context on the other hand.

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Declaration of Ownership

This report is the author's original work.

Conflict of Interest

None.

Ethical Clearance

This study was approved by the author's institution.

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