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Professional networks, scientific collaboration, and publication productivity in resource-constrained research institutions in a developing country

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ABSTRACT

We test the hypothesis that scientific collaboration is associated with increased publication productivity. We differentiate our approach from other studies by (a) incorporating professional networks in the productivity model, (b) casting productivity and collaboration as distinct phenomena, and (c) examining these phenomena in the context of resource-constrained research institutions in a developing country. We use survey data and employ negative binomial regression models. Results indicate that publication productivity is significantly linked to professional network factors, but there is no evidence of any association with scientific collaboration. We observe that most scientists collaborate in research projects despite coordination difficulties, and without any measurable impact on their productivity. Our interviews reveal that a possible answer to this puzzle appears to be rooted in a practice that views collaborative research projects not mainly as a means to producing knowledge and gaining recognition, but for acquiring professional opportunities and extrinsic rewards. Our findings suggest a new way of modeling publication productivity, with implications for science and innovation policy in both the developed and the developing world.

1. Introduction

A mundane, even taken-for-granted assumption underlying scientific research funding, programmatic initiatives and technical support is the importance of collaboration for productivity (Duque et al., 2005; Lee and Bozeman, 2005; Shrum et al., 2007). With the globalization of science and the high expectations for new information and communications technologies (ICTs) in fostering increased interaction between scientists in developed and developing areas, this same assumption is typically extended by funding agencies to research institutions in developing countries (Schofer et al., 2000).[1,2] Indeed, the guiding assumption that collaboration is productive in the context of resource-constrained research institutions has been the basis for foreign-funded projects, technical assistance, and material aid to developing countries (Shrum, 2005).

Yet this connection between joint research work and scientific output is poorly understood in the context of developed world science (Kyvik and Teigen, 1996; Lee and Bozeman, 2005), and virtually untested in the context of the developing world. This led some authors to formulate a collaboration paradox: "the very conditions that make the relationship between collaboration and productivity problematic in developing areas also undermine the collaborative benefits of new information and communication technologies" (Duque et al., 2005:775). Indeed, assumptions can be so appealing that verifying them is construed as academic, especially if these same assumptions are in line with the thematic research thrusts of resource-rich entities in the developed world that understand the developing world based on "views from afar" (Shrum, 1997; Sklair, 2001). With Lee and Bozeman (2005), we argue that such assumptions need verification, especially when they pertain to important science policies and best practices. Unlike other studies, we include professional network factors in modeling productivity, and validate this in resource-constrained research institutions.

This essay in the sociology of science examines the local and the foreign publication productivity of agricultural scientists in two Philippine locations.[3] We begin by discussing recent developments

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[1] By developed countries, we mean the high-income societies in Australia (Australia and New Zealand), East Asia (Hong Kong, Japan, Singapore, South Korea, and Taiwan), North America (Canada and the U.S.), and Western Europe. By developing countries, we refer to the medium- and low-income countries in most of Africa, Asia, and Latin America (Ynalvez and Shrum, 2006, 2008, 2009).

[2] By research institutions, we mean state universities and government research institutes. In developing countries, knowledge production largely takes place in these organizations (Ynalvez, 2006).

[3] Our focus on the agricultural sciences is based on the importance of food production and security in developing countries. Moreover, these are scientific fields

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pertaining to methods of collecting productivity data, and the different measures analysts have employed. Using original survey data, we provide a productivity profile of the population of scientists we study. We then go on to clarify the relationship between scientific collaboration and publication productivity by examining the role of three dimensions: professional networks, graduate training, and Internet utilization.

What relevance is it for analysts in developed countries to examine and understand the dynamics of knowledge production in a developing country? First, we argue that even in developed countries, development is highly uneven. Even with the preponderance of prestigious scientific centers and Research I institutions in developed countries, there are still network regions within the overall research system of a country (e.g., small regional universities) that closely resemble research institutions in developing countries: limited financial resources, inadequate research equipment and facilities, and extreme teaching loads wherein faculty are required to teach at least seven courses in an academic year, but given publication responsibilities as well. The results we present in this article serve to enhance our understanding of the link between collaboration and productivity in resource-constrained research institutions, and inform science policy formulation.

A second reason relates to the unique situation of Philippine research institutions. Due to its strategic location, the Philippines provides an opportunity to examine how postgraduate scientific training of Filipino scientists in three developed countries (Australia, Japan, and the U.S.) shapes these scientists' professional activities.[4] Drori et al. (2003) posit that scientific institutions converge into isomorphic forms. However, if socio-cultural context shapes scientific practice as implied by Callon's (1995) model 4 of science, then the expectation of converging to isomorphic forms may be questionable. Hence, if the hypothesis of Drori et al. (2003) is true then different graduate science training programs should not exhibit large differences in scientists' activities, behavior, and practices.

2. Literature review

2.1. Publication productivity

Research productivity consists of a variety of outputs: collections, inventions, databases, patents, techniques, books, and published papers. Published papers, since they are construed as an indicator of personal merit, represent an important aspect of research productivity (Keith et al., 2002; Ynalvez, 2006). As Callon puts it, "Science is a vast enterprise of writing. . .without it the manufacture of knowledge would be unproductive" (Callon, 1995). A variety of studies have addressed such factors influencing productivity as age (Levin and Stephan, 1991), gender (Fox, 2005; Leahey, 2006; Xie and Shauman, 1998), citizenship (Bozeman and Corley, 2004), and Internet utilization (Vasileiadou and Vliegenthart, 2009; Ynalvez et al., 2005). However, few have considered the crucial role of professional networks in explaining the relationship between scientific collaboration and publication productivity in the resource-constrained research institutions of the developing world. Many data collection methods and measurement techniques have been employed to understand the dynamics of this form of research output. Three methods stand out in the literature: number of published articles derived from bibliometric databases (Kawamura et al., 1999; Leahey, 2006), self-reported productivity measures derived from surveys (e.g., mail surveys in Walsh et al., 2000; face-to-face surveys in Duque et al., 2005), and written papers and publication counts obtained from self-constructed vita (e.g. Lee and Bozeman, 2005).

Although bibliometric techniques result in generally valid and reliable estimates of productivity, they prove inadequate in studying scientific activity in developing countries (Shrum, 2005) because the scientific outputs of the developing world are not well represented in international scientific databases, reflecting differences in priorities as regards local needs and global thematic interests (Gaillard et al., 1997). Self-reported productivity gathered through surveys (Campion and Shrum, 2004; Duque et al., 2005; Walsh et al., 2000; Xie and Shauman, 1998) appears to be a better alternative than bibliometric approaches that either systematically exclude output from developing countries due to differences in thematic emphasis, make it difficult for developing world scientists to publish due to differences in literary style, or utilize less sophisticated methods and techniques owing to resource scarcity.

The curriculum-vitae method of assessing productivity is ideal only if vitae are kept up-to-date and accessible. While they may be used in studying developed-world scientists, it is difficult to employ in the context of the developing world. Experiences from our Philippine surveys highlight a number of problems with this method. First, respondents tend to have no updated vitae. The computer-sharing norm and the location of computers in public areas (Ynalvez et al., 2005) make updating not only difficult, but also a nuisance to our respondents—one that generates psychological stress and considerable attention from kibitzers who are quick to inquire about reasons why one was updating one's vitae (Ynalvez, 2006). Second, even when respondents had a recent copy of their vita, they were often hesitant to provide it as this was construed a confidential and personal document that contained not only professional information but also personal data such as birth date and marital status. For these reasons, and in the absence of truly representative bibliometric databases, self-reported productivity is a more valid and reliable measure of output in the context of research institutions in developing areas.

2.2. Scientific collaboration

Scientific collaboration is defined in many ways (Shrum et al., 2007). For Melin and Persson (1996) and Katz and Martin (1997), scientific collaboration is a form of interaction among producers of knowledge, allowing effective communication and exchange; sharing of skills, competencies and resources; working, generating and reporting findings together. This complex characterization incorporates variable functions that are not inevitable in any given instance of collaboration. In this essay, we view collaboration as the close interaction between two or more scientists in a research project with one or more specific goals—including the simple goal of resource acquisition.[5]

Interaction among knowledge producers is critical to scientific practice (Melin and Persson, 1996). What is important for us is that collaboration is defined by scientists themselves, without

where Filipino scientists are able to participate and gain visibility in international science.

4 Graduate science programs in Australia, Japan, and the U.S. are the top three destinations for Filipino scientists and researchers. In our qualitative interviews and quantitative surveys, we were unable to obtain information as to whether there were significant differences in academic credentials and competencies among scientists and researchers who attended Australian, Japanese, or U.S. universities (Ynalvez and Shrum, 2006, 2008, 2009). We intend to obtain these important pieces of information in future surveys.

5 By project we mean a research undertaking which is carefully thought of, planned, and designed to attain a particular objective, or set of objectives (OED On-line, 2010). A research project can either be 'sponsored,' 'unsponsored,' or both. A professor working with a doctoral student would be involved in a research project, but this would not count as a collaborative research project in our case as we construe collaborative research project to mean working with someone outside one's laboratory or department.

the use of pre-existing criteria. Thus, we conceptualize and measure collaboration not as co-authorship (Endersby, 1996) or data in bibliometric compilations, as many previous studies have done, but rather as self-defined involvement in a joint research effort across organizational units. While we exclude student–professor collaborations, and collaboration between colleagues in the same department or institute, we are able to distinguish between a vital process in knowledge production (i.e., collaboration) and its product (i.e., journal articles). Scientific collaboration emanates from the structure of social relations among knowledge producers. Successful research projects translate into new resources facilitating social actions such as the generation of knowledge through presentation at conferences and journal publication, or the attainment of specified objectives. Consistent with Hackett (2005), our operationalization of collaboration emphasizes two dimensions: *the degree of participation in collaborative activities, and the location of collaborators*. Framing collaboration this way not only allows us to examine the nature of knowledge production in developing countries, but also permits us to study the dynamics of globalization in developing areas through the impacts of graduate training in the developed countries and Internet use (Ynalvez and Shrum, 2008, 2009).

2.3. Professional networks

With the exception of Moody (2004), the distinction between networking and collaborating, and their joint impact on publication productivity has not been adequately studied. Of the social network features described in the literature (Borgatti et al., 1998; Marsden, 2003), we focus on three aspects that relate to network range: size, location, and gender of alter (Cornwell et al., 2008; Ynalvez and Shrum, 2008). Range is that aspect of network diversity in which focal actors are situated, and is indicative of the concentration of interaction on particular types of relations (Hurlbert et al., 2000). Network range is critical to knowledge production because networks having wider range tend to penetrate more deeply into wider scientific institutions, which in turn has implications for access to resources and positions of influence (Borgatti et al., 1998).

Network size is an important indicator of range because larger networks typically translate to greater diversity, provide access to a variety of resources and opportunities, and provide greater access to non-redundant information (McPherson et al., 2006). The locational and the gender aspects of networks are also important indicators of range. Filipino scientists tend to maintain relationships with scientists at their local institution, other domestic institutions, and foreign institutions, notably Australia, Japan, and the U.S. The proportion of ties to developed countries is an indicator of the degree of integration, participation, and involvement in mainstream science (Schott, 1993). More important to an individual scientist in the developing world, connections with the developed countries provide access to greater informational and material resources, so that foreign social relations represent significant social capital that influences prospects for collaboration and ultimately productivity.

2.4. Productivity, collaboration, and professional networks

Aside from the few studies that have examined publication productivity in association with scientific collaboration, few have examined the role of professional networks in productivity. Most studies fail to consider professional networks and scientific collaboration as distinct social phenomena. This distinction was highlighted by Newman (2001), who remarked that many scientists might know each other well, but this does not necessarily mean that they have collaborated or co-authored a paper. In this essay, we frame productivity, collaboration, and professional networks as distinct measurable entities in the knowledge production process.[6] Hence, we hypothesize that professional networks are directly associated with publication productivity, and indirectly through scientific collaborations. In addition to professional networks and collaboration, we include two dimensions that are particularly important in the context of the developing world: location of graduate training and email use.

2.5. Location of graduate science training[7]

Very few analysts have examined the association between graduate training in developed countries and scientific practice (Ynalvez and Shrum, 2006, 2008, 2009). We contend that location of graduate training serves as a venue for the socialization of graduate students not only to the surrounding host culture, but to foreign scientific practice. We further contend that international graduate training, typically lasting from two to five years, is both an opportunity for graduate students to hone technical skills and expose themselves to cutting-edge research, and to acquire social interaction skills that shape their professional activities and careers upon graduation. Two aspects of graduate training are critical in the socialization process: *mode of study* (by research, or by course and research work combined), and *mentoring style* (frequency and intensity of interaction, degree of supervision, and amount of time spent on research) (Ynalvez and Shrum, 2006, 2008, 2009).

In this study, we focus on Filipino agricultural scientists because of the rare comparative opportunity provided by the factors that have shaped Philippine development. This is a population of scientists that has experienced the influence of three scientifically strong countries (Australia, Japan, and the U.S.) through graduate assistantships, material aid, and scholarships. Typically, Filipino scientists receive graduate science training from Australian, Japanese, or U.S. universities, although they occasionally receive a doctorate from a local university. We view Australia, Japan, and the U.S. not as identical loci of 'core science,' but different cultural contexts wherein patterns of interaction and expectations are inculcated (Ynalvez and Shrum, 2006, 2008, 2009).

2.5.1. Japanese graduate science training

Japanese graduate science training not only teaches and hones skills in conducting research using cutting-edge equipment and techniques, but also socializes students into a scientific culture characterized by personal, intense, and frequent interaction with mentors (Ynalvez and Shrum, 2006, 2009). With graduate programs emphasizing hands-on research training over formal academic courses (except for those relating to Japanese language), the socialization process translates to large periods of time working and interacting in the context of the research laboratory. Given the 'personal touch' of interactions, this builds a strong sense of community and working relationship between mentors and students. While the typical work week is from Mondays to Fridays, our informants told us that graduate students were expected to work late into the evening, often Saturdays, and occasionally Sundays (Ynalvez and Shrum, 2006, 2009). This mentoring style and the associated work ethic allow the development of durable and strong ties between mentors and students, extending far beyond graduation (Ynalvez and Shrum, 2009).

[6] In our qualitative interviews, scientists report that knowing someone was a very important consideration when engaging in collaboration. For example, one respondent stated that it he would not collaborate with a 'stranger' or someone whom he did not personally know very well.

[7] The term location of (or place of) graduate science training is consistent with those that appear in Ynalvez and Shrum (2006, 2008, 2009).

2.5.2. U.S. graduate science training

U.S. graduate training not only emphasizes hands-on research, but also formal course work (Ynalvez and Shrum, 2006, 2009). This mode allows students to experience university activities other than those that transpire in the research laboratory. As a result, this reduces the time and opportunity for interaction between mentors and graduate students, interaction that is typically more 'impersonal' and 'business-like' to begin with. The mentoring style in the U.S. encourages independent work. Interactions between mentor and graduate students are less intense and frequent, and the degree of supervision is much less than in Japan. In terms of the time allotted for laboratory research work, Mondays to Fridays are considered working days. While many students do work beyond this, after 5:00 PM and weekends are reserved for family or personal engagements (Ynalvez and Shrum, 2006, 2009). Hence, interaction between mentor and student is more limited. Greater independence results in ties that are loose-knit, weaker, and less durable than those developed in Japanese graduate training (Ynalvez and Shrum, 2009).

2.5.3. Australian graduate science training

Australian graduate training lies at the intersection of Japanese and U.S. graduate training systems (Ynalvez, 2006; Ynalvez and Shrum, 2009). It is similar to that of the Japanese in terms of a mode of study that emphasizes hands-on research training (research experience without formal courses). However, it is also akin to U.S. training in terms of mentoring style, since students have a considerable degree of independence in their daily research activities. Mentors give students a free-hand to go about their lab work, without close supervision, and give them greater independence in terms of planning and decision making. As in the U.S., the typical work week is from Mondays to Fridays (Ynalvez and Shrum, 2006, 2009). Weekends and after office hours are considered time for family and personal use. Our informants said there was no expressed or perceived expectation to work during those times. This combination of mode of study and mentoring style locates Australian training, in terms of the ties between students and mentors, somewhere between Japanese and U.S. training (Ynalvez and Shrum, 2009).

2.6. Internet use

With collaboration becoming a critical process in knowledge production, new ICTs have become the medium for long-distance collaborative work (Olson and Olson, 2000; Vasileiadou and Vliegenthart, 2009). Internet access facilitates communication and the exchange of data vital to knowledge sharing in general and knowledge production in particular (Castells, 2000; Heimeriks and Vasileiadou, 2008). Given the potential for knowledge production as a catalyst for directed social change in the developing world, issues of Internet access and use, and their impact on science in the developing world have become crucial topics for the sociology of science and technology.

Our conceptualization of Internet use is consistent with Lenhart and Horrigan (2003) who view it as more than a dichotomy of use versus nonuse. *Although we recognize the multifaceted nature of Internet use, we focus on a set of specific aspects relating to email use, which is still the most popular use of the Internet in the locations we surveyed*. Hence, we cast Internet use in terms of three aspects of email use related to research: *intensity*, *extensity*, and *diversity* (Ynalvez and Shrum, 2006, 2008, 2009), which has the advantage of examining email use in multiple dimensions and yielding a more content valid operationalization of email use (Lenhart and Horrigan, 2003; Robinson, 2003). In sum, we explore the association between publication productivity, on the one hand; and graduate science training, email use, professional networks, and scientific collaboration, on the other hand. In the next section, we describe our survey and sampling strategies.

3. Data and method[8]

3.1. Sample

In early 2005, we interviewed a random sample of $n = 312$ agricultural scientists in national research institutes and state universities in two Philippine locations: Los Baños, Laguna ($n = 180$), and Muñoz, Nueva Ecija ($n = 132$).[9] Within each organizational setting, we sampled scientists by their place of graduate education (i.e., Australia, Japan, U.S., and the Philippines), making organizational setting and place of graduate education the strata of our sampling strategy (Ynalvez and Shrum, 2006, 2008, 2009). Our survey questionnaire included indicators of professional network size and location, degree of collaborative activity, publication productivity, and email use as well as standard socio-demographic measures.

3.2. Measures

We measure publication productivity using the number of papers published in foreign and in local journals. Both measures are self-reports of output. Each type of publication has some value, but foreign and local publications have markedly different meanings in the Philippine context, both institutionally and for individual scientists. Publications in foreign journals carry greater weight for professional careers than publications in local journals, as standards are perceived to be more rigorous and the readership is broader. However, publication in local journals is perceived to be more relevant, more likely to have practical utility and address meaningful concerns and issues for national development.

We conceptualize collaboration in terms of two dimensions: degree of involvement and location. We asked respondents to provide information on up to a maximum of three major research projects, and whether each of these projects was in collaboration with someone in another organization. Working with someone in the same department, or the same research institute as the respondent, that is, a truly 'local' project was not counted as collaboration. For each reported collaboration, respondents were asked to provide additional information about the location of their collaborators. We derive three simple measures of scientific collaboration. *Degree of collaboration* is indicated by a simple count of the number of collaborative projects (0–3). The *locational dimension of collaboration* is measured by dichotomous variables indicating that the respondent was involved in a domestic (1 = yes, 0 = no) or foreign collaboration (1 = yes, 0 = no).

We take an egocentric social network approach to measure the network dimension, constructing a name-generator and name-interpreter for professional contacts (Marsden, 2003). We asked respondents to provide us with names of people with whom they discuss important matters, people who come to them for advice, and those whom they seek advice regarding their research. This technique yields an advice and communication network (Krackhardt and Hanson, 1993) for scientists, somewhat analogous to the 'core network' measured in the General Social Survey (McPherson et al., 2006). We also asked the gender and location of respondents' contacts.[10] As in our measure of collaboration,

[8] The data and some of our measures in this essay are consistent with those used in Ynalvez (2006) and Ynalvez and Shrum (2006, 2008, 2009).

[9] These locations are the two most important sites for agricultural research and education in the Philippines (Ynalvez and Shrum, 2006, 2008, 2009).

[10] Core network, in this operational sense, is not to be confused with the concept of the scientific core, which refers to the scientists in and scientific institutions of the developed world.

we did not include purely local contacts, in the same department (for universities) or in the same research institute (for national research institutes). From this information, we constructed three measures of respondents' professional networks: overall network size, proportion of male contacts, and proportion of contacts in the developed world.

We operationalize Internet use with three measures pertaining to email use relating to research (as mentioned in Section 2.6, emailing is still the most popular use of the Internet in the locations we surveyed): intensity (number of hours in a typical week using email), extensity (number of years using email), and diversity (0 = no diversity, 6 = maximum diversity).[11] The measurement scheme for email use and the one for graduate science training had been developed by Ynalvez and Shrum (2006, 2008, 2009) [12] Our regression models include controls for contextual, organizational, personal characteristics, resources and professional status. Contextual variables include location (1 = Los Baños, 0 = Muñoz), and organizational setting (1 = national research institute, 0 = state university). Personal variables consist of gender (1 = male, 0 = female), age (linear effect; in years), age squared (quadratic effect; in years squared), marital status (1 = married, 0 = not married), and number of children. We also control for the presence of a computer in respondent's personal office (1 = yes, 0 = no), number of people sharing a computer, and membership in professional organizations (1 = yes, 0 = no) (Ynalvez, 2006; Ynalvez and Shrum, 2006, 2008, 2009).

3.3. Analytical strategy

We use different link functions of the generalized linear regression framework, depending on the empirical distribution and level of measurement of our response variables: network size, scientific collaboration, and publication productivity (Long, 1997). Our basic regression model includes contextual factors, email use, and graduate training variables as predictors. Subsequent models build on this basic equation by sequentially entering professional network and scientific collaboration variables, which assume the role of independent variables in earlier models, and dependent variables in later models. Publication productivity, of course, is our ultimate dependent dimension. The regression models we employ include the normal error regression for network variables, normal error and logistic regressions for collaboration variables, and negative binomial regression for productivity variables.[13] Our productivity variables are positively skewed, consistent with previous studies (e.g., Duque et al., 2005; Xie and Shauman, 1998). At the same time, these measures exhibit over-dispersion so that the very restrictive Poisson regression model was rejected in favor of the negative binomial regression model (Hilbe, 2007; Long, 1997).

4. Results

In what follows, we indicate the characteristics of our respondents. We then indicate the general features of Filipino scientists' professional networks and research collaborations and the factors associated with their sizes and locations. Finally, we predict publication productivity (foreign and local) using network, collaboration, and background characteristics.

4.1. Profile of respondents

Table 1 indicates the characteristics of our sample, about half of whom are male, with an average age of about 48 years, married (83%), with over two children (2.15).[14] Most have doctoral degrees (63%), slightly more than half of which were received locally (54%). However, for advanced training abroad the most common locations were Australia (12%), Japan (15%) and the United States (19%). Fewer than half (47%) have a computer in their personal office. Computer-sharing is still the norm, with about 3.64 persons sharing each computer. The large majority (95%) report membership in some kind of professional organization. In terms of email utilization, scientists use email for about 3.4 hours in a typical week (a little over half an hour per work day), have used email for about eight years, and have moderate level of diversity of use.

Table 1 further show that our respondents report about five professional contacts. Most of these ties are to men (62%) and to other local scientists (87%), as expected from other studies of communication in the developing world. However, nearly 13% of professional relationships are with scientists in developed countries. As we expected from preliminary qualitative interviews, most respondents report active involvement in collaborative research projects. The average number of collaborative projects is 1.9, but the mode is three projects. Majority (72%) of our respondents reports having local collaborators, but about one fifth (18%) report having collaborators in the developed countries. In terms of productivity, respondents report an average of 1.87 articles in local journals, and 1.18 articles in foreign journals over 5 years. Publication productivity in both local and foreign journals is positively skewed, consistent with the distribution of productivity in previous studies (Xie and Shauman, 1998; Ynalvez et al., 2005).

4.2. Professional networks

Table 2 presents the results of regressing professional network size on background, email use and graduate training variables. Results indicate that working in national research institutes ($b = 1.16$) and diversity of email use ($b = 0.38$) are associated with increased network size. This significant association with sector is suggestive of the greater emphasis in developing countries on applied research, which typically addresses local concerns and is a pragmatic approach to knowledge production given limited resources. For instance, research and extension workers have more opportunities than faculty to travel and attend conferences and trainings, where they are able to meet people and establish pro-

[11] A large majority of the scientists in our random sample had first used email in the workplace. Email connection at home was extremely rare even in 2005. Consistent with Ynalvez and Shrum (2006, 2008, 2009), we measured diversity of email use related to research as the summated rating of responses to six questions answerable by either 'yes' (1) or 'no' (0). In our survey questionnaire, these queries were stated as follows: "Have you ever done the following on email: (a) Been a member of a discussion group concerned with science and technology issues, (b) Sent a message to a discussion group concerned with science and technology issues, (c) Discussed research with someone in the U.S., Europe or other developed country, (d) Started a professional relationship with someone you met on the Internet, (e) Discussed proposals with funding agencies, (f) Submitted and/or reviewed manuscripts for journals" (Ynalvez and Shrum, 2006, 2008, 2009). The resultant summated rating scale ranges from no diversity (0) to maximum diversity (6).

[12] Graduate science training was measured by using two variables: level (1 = Ph.D., 0 = Masters) and place (Australia, Japan, U.S., and Philippines) (Ynalvez, 2006; Ynalvez and Shrum, 2006, 2008, 2009).

[13] We used negative binomial regression models because our dependent variables (i.e., number of publications in local and foreign journals), are counts, positively-skewed (or large values being rare), and exhibit over dispersion (Hilbe, 2007; Neter et al., 1996). Although Poisson regression is considered the standard approach in modeling positively-skewed count data, it is not appropriate in our case because the Poisson regression assumption of the mean being equal to the variance is violated in the case of our data (Hilbe, 2007; Neter et al., 1996).

[14] Some entries in our tables may resemble those found in Ynalvez (2006) and (Ynalvez, 2006, 2008, 2009) because our dataset and some of our measures are consistent with those used in these cited materials. In this essay, however, we employ different models and different analytical strategies in examining the roles that professional networks and scientific collaboration play in publication productivity.

Table 1
Descriptive statistics.

Variables	*N*	Mean	SD
Contextual variables			
Location (1 = Los Baños, 0 = Muñoz)	315	0.57	0.50
Sector (1 = research, 0 = academic)	315	0.33	0.47
Personal characteristics			
Age (in years)	315	47.89	7.99
Gender (1 = male, 0 = female)	315	0.51	0.50
Marital Status (1 = married, 0 = not married)	315	0.83	0.37
Number of children	315	2.15	1.33
Resources and professional status			
Computer in Personal Office (1 = yes, 0 = no)	310	0.47	0.50
No. of people sharing office computer	311	3.64	3.78
Member of professional organizations (1 = yes, 0 = no)	314	0.95	0.22
Internet use			
Hours in a typical week using email	300	3.36	3.75
Years using email	304	8.09	3.87
Diversity of email use related to research (6 = diverse, 0 = not diverse)	304	2.88	1.94
Graduate training			
Has a PhD (1 = yes, 0 = no)	315	0.63	0.48
Australian trained (1 = yes, 0 = no)	312	0.12	0.32
Japanese trained (1 = yes, 0 = no)	312	0.15	0.36
United States trained (1 = yes, 0 = no)	312	0.19	0.39
Professional network			
Total number of contacts	315	5.26	3.25
Proportion of contacts who are male	305	0.62	0.32
Proportion of contacts in the developed countries	305	0.13	0.21
Scientific collaboration			
No. of collaborative projects (0–3)[a]	282	1.91	1.08
Has domestic collaborators (1 = yes, 0 = no)	315	0.72	0.45
Has collaborators in the developed countries (1 = yes, 0 = no)	315	0.18	0.39
Research productivity			
No. of articles in local journals	313	1.87	3.67
No. of articles inforeignjournals	313	1.18	2.26

[a] We solicited up to a maximum of three major projects covering the period January 2000 to December 2004.

fessional relationships. The association with sector could also be suggestive of the inability of scientists in state universities to travel due to heavy teaching loads of three to four courses and require intensive preparation and supervision (e.g. laboratory classes). Among our email use variables, only email use diversity had a positive association with network size (Table 2). Extensity and intensity of email use, measured in number of years and in number of hours in a week using email, respectively, have no significant association with network size.

For proportion of contacts who are male, being a male scientist ($b = 0.21$), having a computer in one's personal office ($b = 0.08$), and email use diversity ($b = 0.02$) are significant correlates. Location,

Table 2
Normal error regression results for professional network variables.

Independent variables	Network size	Proportion of contacts who are male	Proportion of contacts in the developed countries
Intercept	4.72	0.46	0.62
Contextual variables			
Location (1 = Los Baños, 0 = Muñoz)	−0.62	−0.04	−0.01
Sector (1 = research, 0 = academic)	1.16**	−0.01	0.08**
Personal characteristics			
Age (linear effect, in years)	−0.07	0.00	−0.03*
Age squared (quadratic effect, in years squared)	0.00	0.00	0.00*
Gender (1 = male, 0 = female)	−0.52	0.21***	−0.03
Marital status (1 = married,,, 0 = not married)	0.21	0.09	−0.03
Number of children	0.35	0.00	−0.02*
Resources and professional status			
Computer in personal office (1 = yes, 0 = no)	0.26	0.08*	0.03
No. of people sharing office computer	−0.03	0.00	0.00
Member of professional organizations (1 = yes, 0 = no)	0.07	−0.02	0.07
Internet use			
Hours in a typical week using email	0.04	0.01	0.00
Years using email	0.07	−0.01	0.00
Diversity of email use related to research (6 = diverse, 0 = not diverse)	0.38***	0.02*	0.02*
Graduate training			
Has a PhD (1 = yes, 0 = no)	0.77	0.02	0.07*
Australian trained (1 = yes, 0 = no)	−0.76	0.05	0.14***
Japanese trained (1 = yes, 0 = no)	−0.96	0.11	0.18***
United States trained (1 = yes, 0 = no)	−0.18	0.08	0.12***
Coefficient of determination (*R*-square)	0.18	0.27	0.27

* Significance at the 5% level.
** Significance at the 1% level.
*** Significance at the 0.1% level.

Table 3
Normal and logistic regression results for scientific collaboration.

Independent variables[a]	No. of collaborative projects[b]	Has domestic collaborators (l = yes, 0 = no)	Has collaborators in the developed countries (l = yes, 0 = no)
Intercept	−1.24	−8.80**	−17.98
Contextual variables			
Location (l = Los Baños, 0 = Muñoz)	0.03	0.53	−0.12
Sector (l = research, O = academic)	0.10	0.53	0.92*
Personal characteristics			
Age (linear effect, in years)	0.08	0.33	−0.22
Age squared (quadratic effect, in years squared)	0.00	0.00	0.00
Gender (l = male, 0 = female)	0.31 *	0.77 *	0.47
Marital status (l = married, 0 = not married)	−0.04	−0.17	−1.00
Number of children	−0.02	−0.02	0.06
Resources and professional status			
Computer in personal office (l = yes, 0 = no)	0.19	0.04	0.05
No. of people sharing office computer	0.02	0.07	−0.02
Member of professional organizations (l = yes, 0 = no)	0.24	−0.82	18.97
Internet use			
Hours in a typical week using email	−0.02	−0.07	0.01
Years using email	0.01	0.08	0.04
Diversity of email use related to research (6 = diverse, 0 = not diverse)	0.11**	0.25**	0.13
Graduate training			
Has a PhD (l = yes, 0 = no)	−0.22	−0.13	−0.04
Australian trained (l = yes, 0 = no)	0.18	−0.46	0.21
Japanese trained (l = yes, 0 = no)	0.30	−0.18	0.33
United States trained (l = yes, 0 = no)	−0.03	−0.29	0.12
Professional network			
Total number of contacts	0.05*	0.04	0.15**
Proportion of contacts who are male	−0.27	0.51	0.28
Proportion of contacts in the developed countries	0.10	0.11	2.04*
Coefficient of determination (*R*-square)[c]	0.12	0.20	0.27

[a] *, ** Significance at the 5% and 1% level, respectively.
[b] Normal error regression for number of collaborative projects; binary logistic regression for other dependent variables.
[c] Except for number of collaborative projects, coefficients are the Nagekerke correction of the Cox and Snell technique.

sector and graduate training are not associated with proportion of male contacts. For proportion of contacts in developed countries, sector (*b* = 0.08), linear effect of age (*b* = −0.03), quadratic effect of age (*b* = 0.00), number of children (*b* = −0.02), email use diversity (*b* = 0.02), having a PhD (*b* = 0.07), and having obtained a final degree from developed countries (Australia, *b* = 0.14; Japan, *b* = 0.18; United States, *b* = 0.12) are significant correlates. Scientists in national research institutes, who are younger, who have few children, exhibit diverse use of email related to research, are doctorates, and have received graduate training in the developed countries, have higher proportions of contacts in these countries. It is clear from these results that although working in national research institutes and exhibiting diverse use of email are significant factors in having ties to developed countries, graduate training in the developed countries is a significant correlate. The salience of graduate training in our findings could well indicate that tacit technical and interaction skills learned abroad have implications for building professional ties in those locations.

4.3. *Scientific collaboration*

Table 3 presents models predicting the extent of domestic, foreign, and all collaborations. We saw in Table 1 that scientists report an average of about two collaborative projects (1.91), most of which are within the country. From Table 3, it is clear that number of collaborative projects is significantly associated with gender (*b* = 0.31), diversity of email use related to research (*b* = 0.11), and professional network size (*b* = 0.05). Put another way, male scientists, those who exhibit diverse use of email related to research, and those who have large professional networks report greater collaboration. As in the case of professional networks, our results point to the importance of gender, and email use diversity that are synergistic with new digital technologies.

Given that local collaborations are the largest component of collaboration, it is not surprising that gender (*b* = 0.77) and diversity of email use related to research (*b* = 0.25) are significant predictors in model 2 of Table 3. Male scientists and those who exhibit diversified use of email report having domestic collaborators. For collaborations with scientists in developed countries, sector (*b* = 0.92), professional network size (*b* = 0.15), and proportion of contacts in the developed countries (*b* = 2.04) are significant predictors. In other words, scientists who are in national research institutes, with larger networks, and a higher proportion of contacts in the developed countries are more likely to have collaborators there. But we also observe that no graduate training variables are significantly related to foreign collaboration.

4.4. *Publication productivity*

We have examined the factors associated with the size and location of networks and collaboration. Our primary goal in this study was to determine their relationships with the products of research work in both foreign and domestic journals. Our final models, therefore, show the factors associated with publication productivity in these outlets. In contrast to previous studies (Xie and Shauman, 1998), we examine productivity by adding aspects of email use and of professional network, and location of graduate training in our model.

4.4.1. *Productivity in local journals*

In this section, we investigate factors that are associated with productivity in local journals. Table 4 column 3 indicates that being younger, having a doctorate, larger network size, and smaller proportion of contacts in the developed countries are associated with number of articles published in local journals, net of other factors. In other words, as far as publication productivity in local journals

Table 4
Negative binomial regression results for local and foreign publication productivity.

	No. of articles in local journals			No. articles in foreign journals		
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Independent variables	Ml	M2	M3	Ml	M2	M3
Intercept	3.34	3.01	3.85	0.31	1.46	0.65
Contextual variables						
Location (l = Los Baños, 0 = Muñoz)	0.35	0.22	0.26	−0.09	−0.17	−0.13
Sector (l = research, 0 = academic)	0.08	0.05	0.04	0.06	0.02	−0.02
Personal characteristics						
Age (linear effect; in years)	−0.28*	−0.22	−0.28*	−0.24	−0.27*	−0.24
Age squared (quadratic effect; in years squared)	0.00*	0.00*	0.00*	0.00	0.00*	0.00
Gender (l = male, 0 = female)	0.10	0.23	0.14	−0.30	−0.34	−0.31
Marital status (l = married, 0 = not married)	0.11	0.10	0.10	−0.17	−0.17	−0.15
Number of children	0.00	0.06	−0.02	0.00	−0.01	0.02
Resources and professional status						
Computer in personal office (l = yes, 0 = no)	−0.01	0.02	−0.04	0.44*	0.43*	0.40
No. of people sharing office computer	−0.04	−0.05*	−0.04	0.05	0.04	0.04
Member of professional organizations (1 = yes, 0 = no)	0.83	0.81	0.69	1.41	1.64	1.42
Internet use						
Hours in a typical week using email	0.01	0.01	0.01	0.02	0.02	0.02
Years using email	0.02	0.02	0.02	0.09**	0.08**	0.08*
Diversity of email use related to research (6 = diverse, 0 = not diverse)	0.12*	0.09	0.07	0.27***	0.27***	0.27***
Graduate training						
Has a PhD (l = yes, 0 = no)	0.85**	0.81**	0.89**	1.26***	1.37***	1.22***
Australian trained (l = yes, 0 = no)	0.04	−0.20	−0.03	−0.13	0.03	−0.14
Japanese trained (l = yes,0 = no)	0.26	0.08	0.27	0.62*	0.76**	0.58
United States trained (l = yes, 0 = no)	0.07	0.03	0.09	0.25	0.27	0.21
Professional network						
Total number of contacts	0.10**	–	0.11***	0.02	–	0.01
Proportion of contacts who are male	0.51	–	0.50	0.21	–	0.12
Proportion of contacts in the developed countries	−1.36**	–	−1.24*	0.93*	–	0.98*
Scientific collaboration						
No. of collaborative projects (0–3)	–	0.19	0.13	–	−0.11	−0.04
Has domestic collaborators (l = yes, 0 = no)	–	−0.46	−0.30	–	0.18	0.09
Has collaborators in the developed countries (l = yes, 0 = no)	–	−0.18	−0.18	–	0.38	0.28
Model χ^2	116.75 (20 df)	84.58 (20 df)	100.63 (23 df)	174.88 (20 df)	151.42 (20 df)	153.95 (23 df)
Deviance	310.85 (264 df)	309.00 (247 df)	281.67 (237 df)	220.07 (264 df)	218.09 (247 df)	207.52 (237 df)
Deviance/df	1.18	1.25	1.19	0.83	0.88	0.88
Partial deviance relative to M3	29.18***	27.33***		12.55***	10.57**	

* Significance at the 5% level.
** Significance at the 1% level.
*** Significance at the 0.1% level.

is concerned having a doctorate, and adding a professional contact are associated with a 143.51%, and an 11.63% increase in output. Furthermore, a one unit increase in the proportion of contacts in the developed countries translates to a 71.06% decrease in local output.[15] Since the majority (72%) of respondents report working with a local collaborator and report engaging in two collaborative projects on average (Table 1), it may be considered surprising that none of the collaboration variables is related to the volume of domestic output. These results suggest that human capital (having a doctorate), larger networks, and highly localized (smaller proportion of professional contact from the developed countries) networks are what matters for local publication productivity.

4.4.2. *Productivity in foreign journals*

Results from Table 4 column 6 depict a different set of factors that are associated with visibility in foreign journals. Years of using email, email use diversity, having a doctorate, and a larger proportion of contacts in the developed countries are associated with enhanced output in foreign outlets. In other words, an additional year of email use experience, a one unit increase in email use diversity, and having a doctorate are associated with an 8.33%, 31.00%, and 238.72% increase in foreign journal output, respectively. In addition, a one unit increase in the proportion of contacts in the developed countries is associated with a 166.45% increase in foreign outlet productivity. Like the results for local productivity, those for foreign productivity reveal no significant association with scientific collaboration. Our results highlight the centrality of advanced academic credentials; a cosmopolitan professional network, digital experience and variety of use in enhancing output in foreign outlets.

4.5. *Problems of collaboration*

The non-significant influence of scientific collaboration on local (Section 4.4.1) and foreign (Section 4.4.2) publication productivity lead us to ask ourselves why this is so. Are research collaborations so fraught with problems that collaborations rarely result to published output? In Table 5, we examine the bivariate correlation of collaboration variables with respondents' perceived problems through

[15] From the negative binomial regression results of productivity in local journals shown in Table 4 Column 3, the calculations are as follows: for having a doctorate where $b = 0.89$, $100 \times [\exp(0.89) - 1] = 143.51\%$; for network size where $b = 0.11$, $100 \times [\exp(0.11) - 1] = 11.63\%$; and for proportion of contacts in the developed countries where $b = -1.24$, $100 \times [\exp(-1.24) - 1] = -71.06\%$. The same manner of calculating applies to the results pertaining to productivity in foreign journals.

Table 5
Spearman rank correlation results for scientific collaboration and research problems.

Research related problems[a]	No. of collaborative projects[b]	Has domestic collaborators (l = yes, 0 = no)	Has collaborators in the developed countries (l = yes, 0 = no)
Problem with coordinating schedules	0.16**	0.12*	0.04
	281	281	281
Problem with resolving conflicts	0.14*	0.19***	0.07
	279	279	279
Problem with dividing work	0.15**	0.21***	0.02
	281	281	281
Problem keeping others informed of progress	0.19***	0.15**	0.07
	281	281	281
Problem with too much information	0.09	0.17**	0.03
	277	277	277

[a] Each problem area was rated on the following scale: l = not a problem, 2 = minor, 3 = major.
[b] In a row, the number on top is the Spearman rank correlation estimate, the one below is the sample size.
[*] significance at the 5% level; all of which are 1-tailed tests.
[**] significance at the l% level; all of which are 1-tailed tests.
[***] significance at the 0.1% level; all of which are 1-tailed tests.

Spearman rank correlation analyses.[16] The extent of collaboration (number of collaborative projects) is significantly correlated with problems of coordinating schedules, resolving conflicts, dividing work, and keeping other informed of progress. Stated in another way, the more a scientist collaborates, the more problems s/he has with coordination, communicating, and information flow. Yet when we examine the location of collaboration, we observe an interesting pattern. It is not collaboration with developed countries that is related to these perceived difficulties. Rather, it is local collaboration that is fraught with problems. We will connect these results to our discussion on the relationship between scientific collaboration and publication productivity later in Section 5.3.

5. Discussion

The results above indicate (1) that graduate training in the developed countries is important through specific processes of networking; (2) that both email proficiency and professional networks are important to collaboration and productivity; and (3) that scientific collaboration among our respondents is less about productivity than about extrinsic rewards. We discuss each of these results, together with some comparisons to prior work on collaboration and productivity in the developing world.

5.1. Graduate science training

Graduate science training in the developed world provides more than scientific skills. For Filipino graduate students, it is an opportunity for them to form and build relationships with scientists in Australia, Japan, and the U.S. International graduate training enable them to socialize and network with others (e.g. classmates, professors, and mentors) in their field, and to acquire social skills that help build rapport and pave the way to career opportunities. In other words, graduate training in the developed countries opens an opportunity for developing world scientists to link closely with leading scientists and experts. International graduate training impacts collaboration via professional networks, but in different ways in different places. Graduate training in the developed countries does not translate into expanded professional network size. Instead, it enhances the proportion of contacts in these countries. In addition, international graduate training impacts publication productivity in journals via professional networks in developed countries, but again in different ways for different publication outlets.

Put another way, graduate training in the developed countries serves as an opportunity to form professional relationships in these countries. The formation of these relationships, however, does not translate to a significant expansion or reduction of respondents' overall network size, implying that while professional network size remains stable, it is ratio between local and foreign contacts within a network that changes. Consequently, proportion of contacts in the developed world has implications on two important scientific activities: research collaboration and publication productivity. As far as the former is concerned, having a higher proportion of contact in the developed countries is directly associated with greater degree of collaboration and collaborative opportunities in the developed countries. As regards publication productivity, having more professional relationships in the developed countries translates to having more articles in foreign journals, but significantly less articles in local journals.

Despite the differences in mentoring styles and modes of study among Australian, Japanese, and U.S. graduate training programs, we did not detect any significant differences as regards to networking, collaboration, and publication productivity. However, we did detect differences between those trained in the developed world (Australia, Japan, and U.S.) and those trained locally (Philippines) on that aspect of professional network pertaining to proportion of contacts in the developed world. Our results point to the need for further research regarding the contextual embeddedness of graduate science training systems and their impact on scientists' professional activities and careers.

5.2. Professional networks, email use, and publication productivity

Network size is important in determining the degree of scientific collaboration, and the likelihood of having collaborators in the developed countries. A large network with a high proportion of contacts in the developed countries results in more collaborative projects with mainstream scientific communities. The size and diversity of informal and non-contractual relationships are crucial in establishing collaborative research projects that are often formalized through contracts, written documents, and terms of reference (Holland, 2009).

Publication in local and foreign journals has different meanings among Filipino agricultural scientists and also different predictors. The location of one's professional network is associated with the publications: higher proportions of contacts in the developed world

[16] We consider five problem areas: (a) problem with coordinating schedules, (b) problem in resolving conflicts, (c) problem with dividing work, (d) problem with keeping others informed of progress, and (e) problem with too much information. Each problem area was rated using the following ordinal scale: 1 = not a problem, 2 = minor problem, 3 = major problem.

are associated with increased foreign publications and reduced local publications. This is consistent with prior arguments that distinguish between scientists with an orientation to local problems and 'externally-oriented' scientists that are focused on cutting edge contributions, but oriented towards the creation and dissemination of knowledge that benefits the local area (Shahidullah, 1991; Shrum and Campion, 2000).

The importance of the Internet can be viewed in this connection: diversity of email use that are related to research is the factor, above all other, most consistently associated with professional networks, collaboration, and productivity: (1) network size and proportion of male and developing country contacts, (2) degree of collaboration (and domestic collaboration), and (3) publications in foreign outlets. Although the Internet has been hailed as a technology that would connect scientists and foster non-collocated interactions, our results suggest that such optimism comes with important caveats. First, email use is associated with publication in foreign outlets but not local outlets. With the shift to online submission, review, and publication it may not be surprising that Internet access and skills are now a requirement for participation in international science. Second, extensity (use over time or years) and intensity (hours of use in a week) of email use, by themselves, do not readily translate into larger professional networks. It is simply not enough to be an avid or long term user. Learning and diversifying email use that are related to research are critical in realizing the positive impact of the Internet in developing larger and extended (international) networks and in greater publication productivity in foreign journals. This is far from saying that experience with ICTs is not important – of course it is. But, diversifying email use related to research is crucial in appropriating the capabilities of ICTs in generating social capital.

The most obvious difference between the predictors of local and foreign productivity is related to use of the Internet, more specifically email use. For productivity in foreign – but not local – journals, email use and experience has a positive impact. Prior work has shown that email use diversity in research enhances foreign journal productivity in the Kenyan and Indian research systems (Ynalvez et al., 2005). The results here corroborate these findings showing the positive benefits of the Internet for developing country scientists in terms of publications in foreign journals. It is not simple availability that matters, but the way in which the email is used. Harnessing the advantages of ICTs in resource-constrained research systems requires extensive and diversified use. *We cannot argue, based on this cross-sectional data, that the usage of electronic communication is causally prior to foreign productivity (that is, it may well be that those who are oriented towards international publication are more likely to develop this behavior). However, our analysis clearly shows that the scholarly attention devoted to the diffusion, the practices, and the meanings of ICTs for scientists in developing areas is not misplaced.*

Local publication productivity is higher for young scientists, those with PhD training, larger networks, and a high proportion of local contacts, but collaborative relationships have no impact. In other words, greater human capital and an extensive local support network translate into productivity in local outlets, but the formal and structured relationships crystallized in research collaborations do not. If this is the case, what constitutes as tangible output and measurable outcomes when research projects come to a close? This result is intriguing because it seems inconsistent with both the widespread assumption that collaborations are productive and our own initial hypothesis that collaborations would be an important factor in productivity (either local or international). Instead, professional networks influenced turned out to be important. This result even becomes more intriguing because a great majority of respondents collaborate despite the fact that collaborations have little to do with local journal productivity.

Compared to other areas, even in the developing world, productivity is relatively low, less than one article per year, on average, even combining both local and foreign publications.[17] On average, our respondents generated 0.60 article per year, while scientists from Ghana, Kenya and Kerala 0.72, 0.50 and 1.40 articles per year, respectively (Ynalvez et al., 2005). Our respondents attribute these low levels to the following reasons: (1) inadequate governmental support for research, (2) out-dated equipment and scarce material resources, (3) frequent power outages, (4) differences in thematic emphasis, methodology, and the publication culture of foreign journals that result in local submissions being 'weeded-out,' (5) the counter-productive effect of heavy teaching loads, combined with the large amount of time needed to publish in scientific journals.

5.3. Scientific collaboration and publication productivity

Finally, the results here indicate that scientific collaboration does not have any direct association with either local or foreign publication productivity for our sample of Filipino scientists. While there is a relationship between network factors and the degree of collaboration—both network size and proportion of contacts in the developed countries are associated with collaboration in the developed countries—we can only conclude that having a broad and diverse network allows access to positions of influence (Borgatti et al., 1998) that often spell the difference between having and not-having access to collaborative projects. But the assumption commonly held by science policy-makers and funding agencies that collaborations are productive is not broadly supported, at least in the context of resource-constrained research system we examined. It has been argued elsewhere that the necessity of some sorts of collaborations, driven by the desire for new and complex instrumentation or resource intensive projects, has been confused with the idea that collaborations are beneficial and productive (Shrum et al., 2007). Even so, this perception derives from the research institutions of the developed world. *What is apparent from these results is that informal and non-structured professional network ties, and not the formal and structured collaborative groups, matter for publication productivity.*

The general reason for the absence of a collaboration-productivity relationship was suggested in Table 5. The rigid structure and the hierarchy of positions that characterize funded collaborative research groups and the spatial dispersion of group members[18] coupled with limited material resources result in difficulties coordinating schedules, resolving conflicts, dividing work, and information management, all of which could be suppressing an underlying positive relationship between collaboration and productivity, if one exists. The degree of collaboration is significantly linked with having coordination and communication problems, and these problems occur more for in-country (local) collaborators than external collaborators. Why? First, it could be that collaborators from the developed countries are able to pump-in resources and technologies that attenuate problems of communication, coordination, and information overflow. Second, it might be that foreign collaborators are typically former advisers, mentors, or professors of our respondents so that they are likely ready to assist and to help their advisees, mentees, and students in their professional careers. Third, it could be the case that collaborators in the developed countries have more extensive and richer social capital than

[17] Productivity in local and foreign outlets was comparatively low relative to those observed in Ghana and Kerala, India; but higher than those of Kenya over the same period (Ynalvez et al., 2005).

[18] Our respondents collaborate mostly with scientists who are based in other domestic locations. Although collaborators are domestic, they are typically not in the same location as respondents.

local collaborators, and as such are better connected and positioned in dealing with problems of allocating and dividing work, and of processing large amounts of information. Or, it could also be that collaborators in the developed countries, owing to their extensive and richer social, and better material resources are able to choose and select the foreign research projects that they would collaborate and engage in.[19]

Fourth, it could be that collaborative relationships among locals, owing to similarities in characteristics, expertise and resources, tend to be more competitive than cooperative; while collaborative relationships with scientists in the developed countries owing to dissimilarities in characteristics, expertise, and resources tend to be more cooperative than competitive. Finally, use of the Internet is widespread among scientists in developed countries and our qualitative interviews suggest that Filipino scientists may have an easier time communicating with colleagues abroad than in their own country, where Internet access and use maybe more widespread in premier research organizations, like the ones we examined, but not in the other research organizations spread across the country. As such, regular email habits may actually reduce collaborative problems, though they do not lead to any relationship between collaboration and productivity, independent of email use.

Future sociological studies need to focus squarely on the question: Why do most scientists collaborate despite its problems and despite no links to the publication productivity that is so important to evaluation processes? Filipino agricultural scientists actively engage in collaborations, write the terminal reports required by funding agencies, but are not highly motivated to publish results in scholarly journals in terms of their internal reward system. Collaborative research projects offer opportunities for other forms of rewards that are more attractive than publishing. Examples are (a) domestic and foreign travel opportunities, (b) supplementary income from honoraria and per diems, and (c) deference and high esteem from colleagues. Once required reports are submitted to and accepted by sponsoring agencies, scientists often terminate the project prematurely, and do not bother with the additional time and effort required to publish results in scholarly journals. Without any guarantee for acceptance and with the dismal prospects for salary increases due to the risk of rejected submissions, publishing in scholarly journals is not really seen as an attractive goal. Instead, scientists would rather divert their efforts to searching for new research projects where prospects for travel, pecuniary rewards, and prestige are probable outcomes. *This is not to say that publishing in scholarly journals is not important—all of our respondents accept that it is—but this is mainly or only symbolic*. As opposed to publications, collaborative research projects are construed as practical and lucrative, as they entail not only symbolic but also equally attractive travel opportunities and pecuniary rewards.

Are collaborations so fraught with problems that these stifle the productive potential of joint research work? We suggest that the answer is yes. Our respondents report sharing computers and landline phones, which was more the rule than the exception.[20] Others report that of the few computers with ready Internet access, connectivity is slow and unstable with high chances of being bounced-off in the middle of writing an email. In one research institute, the problem was not really a matter of hardware or software, but of cables being stolen. Collaborative relationships among local scientists, owing to similarities in credentials, expertise and limited resources, tend to be competitive than cooperative. This relationship often leads to coordination and communication problems.

5.4. Gender differences in networks, collaboration, and productivity

In Table 2, we observed no gender differences with respect to the size of professional network and the proportion of contacts in the developed countries, but find a highly significant disparity with regards to the proportion of male contacts. In other words, male scientists are more likely to have male contacts than female scientists. A possible explanation for this disparity is that even as males and females have nearly equal representation in Philippine research institutions and tend to develop – more or less – the same size of professional networks, there appears to be a tendency among Filipinos scientists to form friendship patterns which are local and gender-homophilous (McPherson et al., 2001). Although changing, these patterns still appear to be largely influenced by a conservative orientation that Filipino culture holds with regards to gender relations, especially so if one was married as most of our respondents were in 2005.

With regards to scientific collaboration, our findings from Table 3 indicate that while there is no detectable gender difference in having collaborators in the developed countries, there is a significant male advantage in number of collaborative projects, and in having domestic collaborators. We suggest three possible reasons. One, female scientists may be at a disadvantage given that they occupy levels and positions (within the research institutions we surveyed) that make it difficult for them to have opportunities for collaboration (Ynalvez and Shrum, 2009), which very much echoes the assertion that "those with authority to influence others and accomplish goals can do so by directing the flow of material and social rewards" (Fox, 2001:663). For example, women commonly occupy jobs in laboratories or offices, whereas men typically occupy jobs that enable them to not only be immersed in laboratory or office work, but also provide them with opportunities to meet and build relationships with others through actual field and extension work. We argue that such aspect of work open opportunities for networking and collaboration.

A second reason may be that female scientists, compared to males, may not have had the opportunity to develop the necessary tacit social skills and behavioral repertoire that would have given them the confidence and the courage to actively pursue collaborative opportunities (Ynalvez and Shrum, 2009). "This may have to do with the traditional Filipino orientation that defines women as appealing, decent, and proper if they are not forthcoming. Women are expected to be reserved and not assertive in initiating relationships or establishing contacts" (Ynalvez and Shrum, 2009:891). A third reason may be that that female Filipino scientists, although active and well-represented in science and research, are still expected to take a prominent role in care-giving and household responsibilities (Lee and Bozeman, 2005; Ynalvez and Shrum, 2009). As such they may have lesser time available and motivation to pursue collaborative opportunities compared to their male colleagues. However, in the specific case of international collaborations compared to local ones, there might be far better incentives (given the higher gains in terms of extrinsic rewards, recognition, and prestige) that even women with their professional and domestic responsibilities are still willing to pursue. Presumably, the reason for not having a significant gender effect on having a collaborator in the developed countries could be that while females tend to be reserved and less assertive than men with respect to prospects for local collaborators, women maybe as assertive and forthcoming as men when it comes to prospects for international collaborations. Hence, women tend to attain parity with men in terms of their propensity to collaborate, which in turn closes the gender gap in having international collaborators.

In contrast to studies in the developed world (e.g., Fox, 1983, 1996, 1999, 2005; Leahey, 2006), we are unable to detect any

[19] We thank the anonymous reviewers for the set of insightful comments that helped us rethink and refine our explanation.

[20] By 2008, the problems with landline phones had been resolved by the widespread adoption of cell phones.

gender differences in local and in foreign journal productivity. Curiously, in the research institutions we surveyed, gender does not play a significant role in published output. From our qualitative interviews, it seems that the amount of time and resources needed to get published outweighs its symbolic rewards when contextualized within resource-constrained (i.e., meager salary, limited supplies and equipment, and limited operating budget) research institutions. For female scientists, who are typically expected to be the ones in-charge of care giving, they spend most of their professional time on non-research activities (e.g. advising, consulting, and teaching), and some of it in performing family-related errands and child-care (Fox, 2010; Fox and Mohapatra, 2010). For male scientists, who are expected to be the bread-winners in the typical Filipino family, they actively pursue collaborative projects, not necessarily to get published or to be recognized in their field, but rather to gain access to extrinsic rewards such as additional income in the form of honoraria, and travel opportunities. It is possible that these shifts from publishing to other activities may have resulted to no particular gender group having higher productivity than the other.

6. Conclusion

In this essay, we showed that in the context of resource constrained research institutions scientific collaboration does not lead to publication productivity. In conclusion, our findings carry important implications for research administration and management of state universities and government research institutes in the developing world, or in network regions within the overall research system of a country (e.g., small regional universities) that closely resemble research institutions in developing countries. Scientists in the developed world are poised to increase their level of collaboration with scientists from developing countries with the objective of conducting research on global concerns (e.g. environmental degradation, decreasing biodiversity, and global warming). Our results suggest a needed reassessment of the collaboration-productivity thesis and the refinement of contemporary scientific productivity models. Before we engage developing country scientists in such efforts, we should seek a clearer understanding of the dynamics of knowledge production to formulate best practices for collaborative efforts, or rethink the discourse of productivity to which we are attached.

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