

PRODUCTIVITY, COLLABORATION AND INTERNET  
PRACTICE IN CHILEAN SCIENCE

By

Ricardo B. Duque

Louisiana State University

[rduque1@lsu.edu](mailto:rduque1@lsu.edu)

## ABSTRACT:

The Internet is emerging as a type of catalyst for global development and knowledge production. This is often supported by its positive material impacts in the First World. However, adoption and use within the Third World is tentative at best. Internet diffusion is often framed by past technology failures in developing areas that further widen global divides.

This paper is quantitative study that investigates how the Internet is shaping science in a Latin American region. It considers the relationship between collaboration, and productivity, focusing on the role of Internet practice by asking, “What is the relationship between collaboration and productivity mediated through Internet practice? Results are presented through a quantitative analysis of a comprehensive communication network survey administered to 337 Chilean researchers. The findings are compared with recent studies on the U.S., African, and Indian scientific communities.

Results suggest that Chilean scientists frequently publish in foreign journals. And in contrast to findings from other developing areas, collaboration is consistently related with increased domestic publication in Chile, suggesting that the Internet may be promoting locally relevant productivity. Although Chileans seldom report problems in research, those they do report are associated with working with more collaborators and having geographically heterogeneous, collaborative networks. Email shows no effect toward reducing the reporting of research problems; and in some cases, email is associated with even more intensive reports of problems.

Key words: Chile, Collaboration, Development, Internet, Publication

## Introduction

Policy studies analyze controversial negotiations between science, industry, and the state, and in particular how expertise is often employed to determine resource distributions. These studies suggest that embedded interests with control over funding steer the process of knowledge production (Vessuri, 1987). However, peripheral actors can sometimes employ system resources to shape alternative outcomes (Epstein, 1996; Jasanoff, 1991; Collins and Evans, 2002). High-level summits sponsored by multi-lateral organizations often replicate the controversial distribution of authority and resources, and negotiate organizational definitions of expertise on a global scale (Crane, 1971; Blume, 1997; Drori, et al., 2003). However, scholars have suggested that such policy discourses reflect the historical friction between socio-economic dependencies and indigenous, cultural practices and ways of knowing (Frank, 1969; Cardoso, 1972; Sagasti, 1973; Frobel et al., 1980; Vessuri, 1987; Escobar, 1995; Sagasti et al., 2003). Two recent examples of global policy discourses are the global knowledge and digital divides.

The dramatic growth and changing nature of global science served to motivate multi-lateral negotiations aimed at reducing the global knowledge divide. Research is now a trans-sectoral, trans-disciplinary, and transnational phenomenon, driven by global economic, environmental, and security concerns (Leydesdorf and Etzkowitz, 1998; Nowotny, et al., 2001; Sagasti et al., 2003). This has often resulted in an erosion of control of individual nation-states in their ability to steer domestic science policy (Blume, 1997; Sagasti et al., 2003). For instance, recently the Millennium Project, sponsored by the World Bank, has promoted cross-national scientific collaboration among scientists located in developing regions. It seeks to improve the productivity of researchers and increase opportunities for advanced training and collaboration (Holm-Nielsen and Agapitova, 2002). This policy initiative is based upon the vast reservoir of

literature espousing the beneficial inevitability of collaboration in northern science over the last four decades (Price, 1963; Crane, 1971; Mullins, 1973; Beaver and Rosen, 1978; Frame and Carpenter, 1979; Bordons et al., 1996; Katz et al., 1996; Hicks and Katz, 1996; Cohen, 2000; Melin, 2000; Kiesler and Cummings, 2002; Hinds and Kiesler, 2002). In general, collaboration is seen as a benefit to projects that employ an intellectual division of labor. The results, in terms of publications for example, are greater than the costs involved in coordination. Yet the accepted study of collaboration through bibliometrics data, on which this optimism is based, has been widely criticized. Although bibliometrics data measures collaboration with co-authorship, these two concepts do not necessarily overlap (Shrum and Shenhav, 1997). Co-authorship can neither determine motivation for collaboration nor identify contributions from particular authors. Moreover, with respect to understanding collaboration in developing regions, bibliometrics considers few journals outside the developed world (Gallaird, 1992). In past studies, researchers argued that because such a large proportion of funding for collaboration originates in the North, it is subject to a process of reagency (Shrum, 2005; Duque et al., 2005). This is a process theory that suggests that often impoverished settings instigate diversion of donor funds to meet local needs at the expense of development goals. As a result, the promotion of cross-national collaboration in some developing contexts may actually retard productivity and waste valuable resources that might have been utilized in other ways (Shrum, 2005; Duque et al., 2005).

Science and technology policymakers expect the Internet to facilitate cross-national collaboration by digitally expanding and restructuring local and global professional networks. This has created a new round of multilateral discussions focusing on efforts to reduce the digital divide. Recent studies on northern science support the positive relationship between Internet use, professional networking, collaboration and publication (Sproull and Kiesler, 1991; Wellman

et al., 1996; Kraut et al., 1996; Walsh and Bayma, 1996; Finholt and Olsen, 1997; Kuko et al., 2000; Quan-Haase and Wellman, 2004; Walsh and Maloney, 2003; Lee and Bozeman, 2005). There is optimism that these digital benefits will be enjoyed by professionals in developing regions as well (Castells, 2000). To temper this progressive assumption, studies on science stratification suggest that a stable asymmetrical core/periphery structure within science disciplines does not benefit the periphery (Merton, 1968; Cole and Cole, 1973; Cozzens, 1990; Guillard, 1991; Schott, 1993; Zuckerman, 1996). Moreover, work on cross cultural technology transfers (Akrich, 1993; Guille-Escuret, 1993; Pfaffenberger, 1993; Cutcliffe et al., 2002) and readings from social network perspectives (Rogers, 1995; Narayan and Cassidy, 2001; Fukuyama, 2003) question the smooth transfer of complex cultural-technical systems into resource-poor regions. Furthermore, the few studies that consider the African scientific community have found little or no positive associations between Internet use, collaboration, and publication (Ehikhamenor, 2003; Duque et al., 2005). Whether this results from social conditions peculiar to sub-Saharan regions or is true more generally is yet to be empirically determined.

In this paper, I consider the relationship between collaboration and productivity within a Latin American context, Chile, to see if recent policy orientation that promote adoption of Northern models of science have the intended effect. I also investigate how Internet practice mediates professional activities to evaluate if new ICTs are associated with attenuating the challenges of conducting science in the Chile. These research goals are accomplished by considering a cross sectional comparison of 337 Chilean scholars, based on 2005 survey data gathered on their collaborative behavior, productivity patterns, and Internet use.

The present analysis is framed by recent studies looking at the interaction between collaboration, productivity, and Internet practice in the United States (Walsh and Maloney, 2003; Lee and Bozeman, 2005) and in Africa and India (Duque et al., 2005). Lee and Bozeman (2005) conclude a positive relationship between collaboration and publication. Walsh and Maloney (2003) find a positive association between the use of email and reporting less intense problems in the research process. Work in the developing context finds mixed results. Duque et al. (2005) first considered the relationship between productivity and collaboration, and then the relationship between email use and problems reported in conducting research for a sample of African and Indian scientists. Their findings suggest an interesting variation across development context. Kenyans tend to collaborate more, report more problems, publish the least, and have the least consistent access to Internet. The Indians, on the other hand, publish most, report fewer problems, collaborate least, and have the most consistent access to the Internet. The study conclusion encouraged caution in (1) promoting collaboration for its own sake, and (2) assuming that Internet technologies represent a panacea for science across every context.

Compared to past regions studied, Chileans are digitally well connected. This is credited to 20 years of digital infrastructure investments begun during the Pinochet dictatorship (Mullin et al., 2000). Also, Chileans enjoy robust international professional networks, perhaps a result of close to 50 percent of PhDs having been acquired abroad (Holm-Nielsen and Agapitova, 2002). This outward orientation may emanate from and be reinforced by an institutional need to publish in high impact ISI journals, many of which are produced in the North. Moreover, many Chilean scholars contend that in order to start projects from which publications result, one must seek a collaborator abroad to access resources (Duque, 2006). The sharp rise in international citations and publications by Chilean scientists in the last decade is credited to the increase in

international collaboration (Hill, 2004). And during the global diffusion of the Internet, there has been a slight increase in publications per Chilean scientist (CONICYT, 2004). But this measure is arguably blunt. The present analysis takes into account background and contextual factors, and known differences between domestic and foreign publication patterns. To find whether Chile's stable growth and advanced Internet infrastructure may lead to differing associations among professional activities, the following describes (1) how this paper measures collaboration and productivity; (2) how collaboration and productivity in Chile are associated, controlling for other factors; and (3) how Internet use is associated with reporting problems in collaboration. I conclude with a discussion.

## **Sample and Method**

This paper's research question concerns the relationship between collaboration and productivity within the Chilean scientific community, mediated by new ICTs. This is addressed through face-to-face survey interviews with 337 Chilean scientists in both academic and research institute settings. Local collaborators in Concepcion and Puerto Montt helped to assemble and direct a team of 14 postgraduate student interviewers. During March and April of 2005, these research assistants conducted interviews with 300 scientists—approximately 3.5 percent of the national workforce of 8500. Face-to face interviews were stratified (1) by research sector—university departments and national research institutes,<sup>1</sup> and (2) across two regions—Concepcion/Chillan and Puerto Montt/Osorno. Due to different distribution patterns by sector, the academic scientists were localized in one region, Concepcion/Chillan, and the research

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<sup>1</sup> Separated by approximately 500 miles, these southern regions are known for marine and agricultural research within both academic departments and in research institutes. Focusing my research in these areas allows me to sample proportionately between these two sectors. I include a list of departments and research institutes included in the sample in the appendix.

institute scientists were initially distributed across two regions, Concepcion/Chillan and Puerto Montt/Osorno. After the first round of interviews, I discovered an imbalance in sampling that favored academic scientists. To balance this, I returned in June 2006 and organized interviews with an additional 37 research institute scientists in Santiago, Chile.

Each researcher was contacted by an administrative assistant. The administrative assistant first acquired authorization from department or institute directors. Then the respective departments or directors faxed or emailed a list of researchers, including phone numbers and email addresses, to the respective units. Since the study concentrated on a select number of university departments and institutes, the decision was to sample all the potential respondents from each unit. This resulted in a response rate of over 90 percent, based on a successfully scheduled and completed face-to-face interview. The refusal rate was minimal and passive, due to the researchers' preparation to be in-field or attending out-of-town conferences.

I used a communication network survey already employed in five other research settings (Kenya, Ghana, South Africa, Kerala in India and the Philippines). The questionnaire included sections on background, professional activities (project directed, collaboration, attending conferences), outcomes (publications and awards), organizational affiliations (academic or research institute), networks (inter/intra-organizational and domestic/foreign), and Internet adoptions, access and practice. This instrument is unique in that it is able to tap both individual and organizational networks and can distinguish various network dimensions. Most relevant, the survey accounts for the critical factor of location. This is necessary in order to assess the relationship(s) between domestic and foreign collaborator(s), publication(s), and network profiles. The survey is understandably limited in accounting for information on all relational

nodes within an individual's network. Therefore, analyses in this paper depend on ego-network measures.

### **Measuring Productivity and Collaboration**

In contrast with studies of scientific productivity that use bibliometric techniques, this present investigation replicates a previous study based upon African and Indian data (Duque et al., 2005). Thus, the research relies on self-reported publication productivity by Chilean researchers. Bibliometrics tend to measure both productivity and collaboration by co-authorship. This results in multicollinearity issues when the dependent and independent variables are derived from the same measure. In addition, bibliometric analysis is based on databases that often do not include Third World journals. As a result, these measures are found to be inadequate as indicators of scientific productivity outside the developed world (Gaillard, 1992; Shrum and Shenhav, 1997). The dependent variables chosen are the number of articles published in national and foreign journals. Graduate interviewers asked each respondent how many articles they published in foreign and in national journals during the last five years. An additive scale is created to measure total publications for some analyses. Because the distribution of publications is positively skewed, this study employs natural logarithms of self-reported productivity in the regression analyses. An additional measure of productivity emerges in the digital age, web-publishing. Respondents were asked to report whether or not they had ever published a paper on the web (1=yes, 0=no). For the regression analysis of this dichotomous and nominal variable, a binary logistic regression is employed.

Control variables considered for the analyses are derived from previous research on scientific productivity. For example, studies have shown the effect of contextual factors on

productivity (Garg and Padhi, 2000; Duque et al., 2005; Lee and Bozeman, 2005). Distance from the core is suggested to limit resource flows (Bradshaw, 1987) and be associated with publication patterns that place the periphery at a disadvantage (Merton 1968; Cole and Cole, 1973; Cozzens, 1990; Moody, 2004). There are institutional variations in the reward criteria assessing academic and research institute scientists (Raina, 1999). Different fields also have been known to reflect varying publication patterns (Lee and Bozeman, 2005; Stephen and Levin, 1992; Moody, 2004). Therefore this study controls for the following contextual factors: Region is measured as Santiago (core) = 1, Concepcion/Chillan (semi-periphery) = 2; Puerto Montt/Osorno (periphery) = 3; Sector is measured as 1=research; 0=academic; and Field is measured by dummy (0, 1) variables for agricultural, physical, natural, engineering, and social sciences.

Publication has been known to vary across social and professional characteristics as well. Many authors (Campion and Shrum, 2003; Goel, 2002; Prpic, 2002) have found gender differences in scientific publications, while others (Gupta et al., 1999) found no significant difference between productivity distributions of male and female scientists. Gender is measured as 1=male; 0=female. Previous research on the effect of Age on productivity has shown that it has a depressing effect (Bonaccorsi and Daraio, 2003), although others have suggested a curvilinear relationship—low in the beginning of careers, peaking at mid-career, and then declining at the end of careers (Cole and Cole, 1973; Stephen and Levin, 1992). Additional controls include education and professional activities: acquired a PhD (1= yes; 0=no); An advanced degree from a developed country (1=yes; 0=no); and professional involvement: Held office in a professional association 1= yes; 0=no; Number of professional meetings attended; and Number of journals subscriptions. Because distributions are positively skewed, this study employed natural logarithm transformations for the self-reported number of professional

meetings attended and journal subscriptions in the regression analyses. A final professional activity controlled for in some analyses is the number of Projects directed, a self-reported continuous variable that is expected to affect: (1) the number of collaborations respondents report, (2) their productivity, and (3) to what extent they report the intensity of problems in conducting research.

Since productivity is often the result of grant funding (Lee and Bozeman, 2005), winning awards is an additional control. Graduate assistants asked respondents to report the number of Individual awards and the number of awards as part of a larger study, Project awards, in the last five years. These two award variables are positively skewed and are represented as a natural logarithmic transformation in the regression analyses.

Publishing in foreign journals is often mediated by contacts in the exterior. The sharp rise in Chilean publications is tied to the increase in foreign collaboration (Hill, 2004). Conversely, domestic publishing may be influenced by local contacts. To control for these network dimensions, Domestic and International networks are controlled for in the analyses. These are measured by the count and location (within Chile and outside Chile) of up to twelve inter-organizational contacts with which respondents worked closely.

Moreover, since I am interested in how Internet practice shapes professional behavior, also included are Weekly hours using email, an ordinal variable outlined in the previous chapter, Years using email, and Email diversity, an additive scale outlined in the previous chapter. Since Chilean researchers are encouraged to publish in high impact ISI journals, many of which are published in English, and the Internet is primarily an English text phenomenon, the study controls for the Language dimension. Graduate interviewers asked respondents to report to what extent they feel comfortable communicating in English (1 = very comfortable, 2 = comfortable 3

= not so comfortable, 4 = uncomfortable). Also, respondents were asked to report the frequency of using English language websites (1 = frequently, 2 = occasionally, 3 = rarely, and 4 = never).

Collaboration is measured in two general ways to allow for the difference between intra and inter-organizational relationships. To measure intra-organizational collaboration, graduate interviewers asked respondents for the number of individuals in the parent organization with whom they work closely. The previous study defined this concept as those with whom they ‘currently discuss projects on a regular basis’ within several distinct categories of collaborators—professionals, technician, and doctoral students. Because the distribution is positively skewed, this present study employs a natural logarithm transformation of self-reported intra-organizational collaborators in my regression analyses. To measure the inter-organizational dimension, I used the extent to which the respondent’s main research projects were collaborative. Each scientist was asked to describe briefly up to three current projects. These items were coded dichotomously and in order to indicate whether the project was collaborative. The Degree of collaboration was indicated by an additive scale measuring the number of collaborative projects (0 to 3). Respondents were also asked to report the location of collaborators in up to six regions per each of three current projects— local, outside local but within Chile, outside Chile but within Latin America, Europe, United States, and other. I recoded this variable by a count of Local collaborators within Chile, and Collaborators located in developing countries. Diverse networks often provide access to new information and resources (Blau, 1977; Popielarz, 1999; Burt, 1983; Lin et al., 2001) that may lead to increased productivity. However, they also may result in coordination difficulties (Rothschild-Whitt, 1979; Sirianni, 1994) that could inhibit productivity. To measure this dimension, Homogeneity of collaboration network, a dummy variable (0, 1),

indicates if a respondent's collaborators are all in Chile, with 'having collaborators both within and outside Chile' as the reference group.

Problems with collaboration was treated by Walsh and Maloney (2003) for a sample of U.S. scientists and Duque et al. (2005) for a sample of African and Indian scientists. This present study used the same index, based on a variety of problematic dimensions associated with the subject's collaborative projects: (a) problems with contacting people, (b) getting others to see your point, (c) security of information, (d) resolving conflicts, (e) coordinating schedules, (f) length of time to get things done, (g) transmitting information, (h) dividing work, and (i) keeping others informed of progress. Coded 1 to 3, subjects self reported whether they thought these dimensions were a major problem, minor problem or no problem at all.

### **Collaboration, Productivity and Email Use - Analyses and Findings**

The following analyses and finding section first describes the key mean distributions of dependent, independent, and control variables. Then the study considers the relationship between collaboration and productivity, first with a correlation of publication by field, and then through various multiple regression analyses by sector and geographic location of publication in domestic or foreign journals. This section concludes with a treatment of email use and problems in collaboration, employing means comparisons and multiple regression analyses.

Table 1 presents basic demographic, educational, contextual dimensions of the Chilean sample with references to findings from a similar study conducted in Africa and India (Duque et al., 2005). Only 23 percent of the Chilean sample are women (line 2), compared to 37 percent in Kerala from the 2000 data. This Chilean figure is higher compared to African figures on female scientists (17%) from 2001-2202. The mean age of the Chilean sample was 48 years (line 3),

approximately the same mean age as African and Indian samples at the time of the previous study.<sup>2</sup> The Chilean sample is less likely to be married, 76 percent (line 4), as compared with 89 percent of African and Indian scientists.

Since the post-colonial period, education and training of scientists in developing regions represents a critical research and policy area (Shrum and Campion, 2000). In the African context, the Africanization of research systems in former colonies was a priority after independence (Phillip, 1976), but now is largely complete. In the Latin American context, it has been a combination of socio-political disruptions with traditionally few local options for advanced degrees across fields that have shaped an outward orientation of advanced training. Table 3.1 indicates the level and location of training for the Chilean sample. Most Chilean scientists have an advanced degree, at least equivalent to a Master's (line 8). For the PhD level (line 9) Chileans are at 58 percent. This is less than the Indian context (75%) but more than the African (40%) is in our previous study.

The place of training is also represented on Table 1. Forty-five percent of Chileans in the sample received a high degree from an institution located in a developed country (line 10). The Africans in the previous survey reported close to two thirds had gotten their advanced degree from a developed country, in contrast to only five percent of Indian scientists. This difference is reflected in the amount of experience abroad, with Chileans spending about 3.9 years in developed countries for training or leisure (line 11). South Indian scientists in our previous study reported rarely traveling outside their country. Most of the African scientists had spent several years in the developed world. The differences between Chilean, African, and Indian scientists are explained by a few primary factors. The earlier study concluded that the opportunities for

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<sup>2</sup> The average age of our African and Indian scientists in 2000-2002 was 44 years old. In 2005 this group would be close to 48 years old (Duque et al., 2005).

**TABLE 1**

**MEANS OF BACKGROUND, EDUCATION AND CONTEXTUAL FACTORS**

	Mean	N
<b><i>Background</i></b>		
1. Gender (% male)	77%	337
2. Age of respondent	48	336
3. Married	77%	337
<b><i>Education</i></b>		
4. Holds an advanced degree	85%	337
5. Doctoral degree	58%	337
9. High degree from developed country	45%	337
10. Years spent outside country for higher education	3.2	336
11. Years spent abroad in the developed countries	3.9	337
<b><i>Sector</i></b>		
12. Academic Department	62%	208
13. Research Institute	38%	129
<b><i>Field</i></b>		
14. Agricultural Sciences	35%	114
15. Physical Sciences	11%	38
16. Natural Sciences	29%	99
17. Engineering Sciences	15%	52
18. Social Sciences	10%	34
<b><i>Region of the Country</i></b>		
19. Santiago (Core)	10.4%	35
20. Concepcion/ Chillan (Semi-periphery)	77.2%	260
21. Puerto Montt/ Osorno (Periphery)	12.5%	42
<b><i>Research Institutes</i></b>		
22. Santiago (Core)	26%	35
23. Concepcion/ Chillan (Semi-periphery)	41%	53
24. Puerto Montt/ Osorno (Periphery)	32%	42
<b><i>PC and Internet Access and Use</i></b>		
25. PC located in office	100%	337
26. Year first used email	1994	336
27. Ready Email Access	100%	335
28. Average Hours using Email in typical week (0 =not at all, 1=less than an hour, 2=between 1 and 5 hours, 3=between 5 and 10 hours, 4=between 10 and 20 hours, 5=over 20 hours)	2.31	337
29. Email Use Diversity	4.2	338

higher education are much greater in India. Thus, Indian scientists travel to a variety of internal research areas for advanced education. In contrast, Kenya, and Ghana have long been the beneficiaries of international donor attention, which is especially focused on scholarships for Africans to study in First World universities. During the qualitative phase of the Chilean study (Duque, 2006), I identified that few domestic doctoral programs are offered across field. This is generally supported in the literature as well (Mullin et al., 2000). The local limitation is augmented by the prestige that accompanies those who train abroad and return. Whether or not successful in their attempts, most Chileans pursue training in the exterior as a result

Furthermore, Table 1 reflects that 62 percent of the sample works in academic departments (line 12), while 38 percent are in research institutes (line 13). By field (lines 14 – 18), the sample broke down as follows: agricultural science (35%), physical sciences (11%), natural sciences (29%), engineering sciences (15%), and social sciences (10%). And by region of the country (lines 19 – 21): Santiago (Core) 10.4 percent, Concepcion/ Chillan (Semi-periphery) 77.2 percent, Puerto Montt/ Osorno (Periphery) 12.5 percent. The academic scientists are all concentrated in the semi-periphery (Concepcion/Chillan), while the research institute respondents (line 22 -24) are distributed as follows: Santiago (26%), Concepcion/Chillan (41%), and Puerto Montt/Osorno (32%). Thus, analyses and findings by region of the country are limited to understanding variations within the research institute sector only.

Finally, one-hundred percent of the respondents report having a PC in their office (line 25) with ready email access (line 27). This is twice the percentage of African access. The Chilean respondents on average report first using email in 1994 (line 26), two years earlier than the Africans and Indians in a previous study (Ynalvez et al., 2005). Chileans respondents report on an average using email over five hours a week (line 28). Finally, their email diversity index

on average is 4.2 out of a possible six categories (line 29). This is greater than the Indians and the Africans from the former study.

### *Describing Professional Activities in Chile*

In measuring productivity using CVs of a sample of U.S. academicians, Lee and Bozeman (2005) found they averaged close to 20 articles in a five year period. As a rough estimate, U.S. publication productivity is four times as great compared to that of Indians and Africans in a previous study. In Chile, the self-reported sum of articles in national and foreign journals is seven (Table 2, line 1). This is on par with the Indian, and significantly more than the African, scientists in the previous study (Duque et al., 2005). The interesting comparison is that although Chileans attend fewer conferences than do other developing world regions studied, the mean productivity in foreign journals by Chileans is twice that of either the Indians or the Africans. This may be a result of the institutional emphasis to publish in high impact ISI journals, the majority of which are located in the North. In addition, 44 percent of Chilean scientists reported publishing on the web (line 4). This is close to three times the percentage of Indian and African scientists from a previous study.

To what extent do scientists in Chile collaborate? As described above, two sets of questions provide indicators of collaboration within and outside the local research organization. Intra-organizational collaboration was measured by the number of individuals with whom the respondent worked closely. Chileans report working closely with 8.5 collaborators within their parent organization (line 5). Collaboration and productivity is not only an intra-organizational dynamic, particularly in the context of development. Collaboration outside one's parent organization involves a different process in much of the developing world (Duque et al., 2005).

**TABLE 2****MEAN OF PRODUCTIVITY, COLLABORATION, ENGLISH PROFICIENCY AND PROFESSIONAL AWARDS & ACTIVITIES**

<b><i>Productivity</i></b>		
1. Total number of articles published in foreign and national journals over the last five years	7	337
2. Articles in foreign journals over the last five years	4	337
3. Articles in national journals over the last five years	3	337
4. Web published (yes)	44%	336
<b><i>Collaboration Frequency and Location</i></b>		
5. Internal Collaborators	8.5	337
6. Any current collaboration	79.5%	337
7.. Number of current collaborations (3 maximum)	2.1	337
8. Number of domestic collaborators over three main projects	2.4	337
9. Number of foreign collaborators over three main projects	1.0	337
10. Exclusively Chilean collaborators	45%	153
<b><i>English Language Dependence and Proficiency</i></b>		
11. Use English Websites (1=frequently, 2=occasionally, 3=rarely, 4= Not at all)	1.3	334
12. English Proficiency (1=Very comfortable speaking English, 5 = Do not speak English)	2.4	337
<b><i>Professional Awards and Activities</i></b>		
13. Projects directed	1.73	337
14. Individual Award	3	335
15. Award as part of a larger project	2	332
16. Journals subscribed to	1.96	336
17. Held office in professional association	52.5%	337
18. Professional meeting attended	8	337

It was suggested repeatedly during a qualitative interviews with Chilean scientists that foreign collaboration fuels local projects because domestic resources are low and bureaucratic obstacles are high (Duque et al., 2006). Taking the lead from the previous investigation, I measured external, or inter-organizational, collaboration as (1) whether the scientist was involved in any collaboration over three main projects, and (2) the degree of collaboration, the sum total of collaborative projects out of three maximum. Seventy-nine and a half percent of Chilean scientists report having any collaboration (line 6). This figure falls just behind the Kenyans and is almost twice that of the Indians in a previous study (Duque et al., 2005). In addition, Chileans reported on the average having 2.1 collaborations out of three possible projects (line 7). This is almost 50 percent more than the African rate and over three times the Indian rate of collaboration.

A dimension not previously accounted for in Africa and India was the number and geographical location of collaborators among the present three projects. In the 2005 Chilean survey, we asked respondents to report in what region collaborators were located (local, outside locale but within Chile, outside Chile but within Latin America, in Europe, in the United States, or other) for each of three current projects. National collaboration seems healthy in Chile, accounting for two thirds of all collaborators. Chileans on average reported 2.4 national collaborators over three current projects (line 8). This contradicts the suggestion that projects are determined by international collaborations due to lack of local recourses and expertise. International collaboration averaged one per respondent (line 9). But 55 percent of respondents reported that they had foreign collaborators in their collaborative network (line 10). Moreover, when deconstructing location of collaborators variable, the study found Latin American collaboration to be low, while dependence on Europe and the United States is high, accounting

for close to three quarters of all international collaboration. This does support an outward orientation of Chilean science toward resource-rich nations and their scientific cultures and away from regional partners that may share relevant issues and culture.

Chile is the only nation included in the project where English is not an official language. Since the Internet is primarily an English language phenomenon, I wanted to control for the dependence on using English language websites and proficiency of communicating in English. Table 2 reflects that on the average, Chileans report more than occasionally utilizing English language websites (line 11). Chileans also report being only marginally comfortable with communicating in English (line 13); although over 50 percent report being comfortable or better when communicating in English.

Unlike the previous study, the 2005 Chilean survey was able to account for grant awards. Respondents averaged two individual and three project funding awards over the last five years (lines 14 and 15). In addition, Chilean scientists averaged 1.73 projects directed (line 13), subscribe on average to almost two journals (line 16), and over 50 percent report holding an office in a professional association (line 17). These last two figures are slightly higher than the Africans and Indians. But Chileans attended an average of only eight conferences over the last five years (line 18). This is half the number reported by the Indians and Africans. In a qualitative study, Chileans consistently commented on the low emphasis placed upon attending conferences (Duque, 2006). The conferences represented an unmanageable expense, were limited in terms of networking, and some mentioned the high degree of in-politicking involved in many them.

### *The Relationship Between Collaboration and Productivity*

To what extent is collaboration associated with publication productivity in Chile? In this section, I examine this relationship, comparing results with previous studies in the U.S. (Lee and Bozeman, 2005), Africa, and India (Duque et al., 2005). Productivity is the dependent dimension, and collaboration is the independent dimension. Fields have been found to vary widely in terms of publication and collaborative behavior (Stephan and Levin, 1992; Lee and Bozeman, 2005). Physical scientists tend to work in large groups and publish heavily. Social scientists generally work in isolation or in small groups and do not publish at the same rate as other fields. To identify the effect of field in the Chilean context, Table 3 presents a correlation of various productivity measures and fields by sector. Academic physical scientists are less likely to publish in domestic journals (column 2, line 1). Academic social scientists are more likely to publish in domestic journals (column 2, line 2), while social scientists in both sectors are less likely to publish in foreign journals (column 3, lines 2 and 7). Agricultural scientists across sectors are more likely to publish in domestic journals (column 2, lines 3 and 8). Engineers across sectors publish less overall (column 1, lines 4 and 9) and are less likely to publish in domestic journals (column 2, lines 4 and 9). Natural scientists across sector are more likely to publish more overall (column 1, lines 5 and 10), and more likely to publish in foreign journals (column 3, lines 5 and 10). These correlations identify two fields that are more and less likely to publish, natural (high) and engineering (low) sciences. In the regression analyses that follow, the study controls for the effect of field with four dummy (0, 1) variables for agricultural, physical, natural and social sciences. Engineering sciences is designated as the reference group.

Table 4 reflects the results of regressing the logarithm of total productivity on collaboration with several important control variables including field. Column 1 provides

**TABLE 3****CORRELATIONS OF FIELD AND PUBLICATION LOCATION**

<b>Academic Scientists (N = 207)</b>	<b><u>Total Publications</u></b>	<b><u>Domestic Publication</u></b>	<b><u>Foreign Publication</u></b>
1. Physical Sciences	-.039	<b>-.183**</b>	.092
2. Social Scientists	-.056	<b>.184**</b>	<b>-.186**</b>
3. Agricultural Scientists	.048	<b>.197**</b>	-.062
4. Engineering Sciences	<b>-.150*</b>	<b>-.168*</b>	-.068
5. Natural Sciences	<b>.158*</b>	-.048	<b>.193**</b>
<hr/>			
<b>Research Institute Scientists (N = 128)</b>			
6. Physical Sciences	-.027	.002	.001
7. Social Scientists	-.117	-.018	<b>-.196*</b>
8. Agricultural Scientists	.078	<b>.311**</b>	-.170
9. Engineering Sciences	<b>-.366**</b>	<b>-.397**</b>	-.168
10. Natural Sciences	<b>.235**</b>	-.034	<b>.374**</b>

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\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

**TABLE 4**

REGRESSION OF TOTAL PUBLICATIONS ON BACKGROUND, EDUCATION,  
PROFESSIONAL ACTIVITIES & AWARDS, NETWORKS, AND COLLABORATION

	Full Sample <sup>a</sup>	Academic <sup>a</sup>	Research <sup>a</sup>
<b><i>Contextual Factors</i></b>			
1. Region (core=1, periphery=3)	-.103**	N/A	-.200**
2. Sector (research institute)	-.158***	N/A	N/A
3. Agricultural sciences	.204***	.181**	.208
4. Physical Sciences	.060	.070	-.031
5. Natural Sciences	.263***	.220***	.374**
6. Social Sciences	.123**	.114	.086
<b><i>Background &amp; Education</i></b>			
7. Gender (male)	-.055	-.033	-.126*
8. Age	.017	-.013	.065
9. PhD	.245***	.254***	.188**
10. Degree from developed country	-.023	.029	-.092
<b><i>Professional Activities and Awards</i></b>			
11. Professional meetings attended <sup>a</sup>	.265***	.246***	.313***
12. Number of journals subscribed to <sup>a</sup>	.111**	.069	.165**
13. Individual awards <sup>a</sup>	.225***	.144**	.316***
14. Project awards <sup>a</sup>	.137***	.175***	.065
<b><i>Networks</i></b>			
15. Size of domestic network	-.065	-.032	-.092
16. Size of international network	-.008	.029	-.057
<b><i>Collaboration</i></b>			
17. Total Collaborations (out of 3 main projects)	.156***	.160**	.104
18. Intra-organizational Collaboration <sup>a</sup>	-.026	-.046	.020
19. R <sup>2</sup>	.443	.376	.591
20. N	326	203	122

\*\*\*, \*\*, \* significant at the .01, .05, .1 levels respectively.

a. Variable is expressed as a natural logarithmic transformation

standardized regression coefficients and levels of significance for a model that explains with eighteen factors, including collaboration measures, close to 45 percent ( $R^2 = .443$ ) of the variation in total productivity for all scientists in the sample. Contextual factors are highly and significantly associated. Total publications favor the core ( $b = -.103$ ), academic scientists ( $b = -.158$ ), and agricultural ( $b = .204$ ), natural ( $b = .263$ ) and social ( $b = .123$ ) sciences. Those closest to the center of funding, Santiago, and those with an institutional imperative to publish (academic scientists) produce the most. Holding a PhD ( $b = .245$ ), more professional meetings attended ( $b = .265$ ), having subscribed to more journals ( $b = .111$ ), and winning more individual ( $b = .225$ ) and project ( $b = .137$ ) awards are also highly significantly associated with higher levels of publication productivity in Chile. In addition, for the full sample, the coefficient for collaboration is highly significant ( $b = .156$ ): collaboration is related to total productivity in the Chilean context. This contrasts the results from the previous study in India and Africa, where collaboration was not found to be significantly associated with total publications. Columns two and three in Table 4 shows the results of estimating the model separately for respondents in universities ( $R^2 = .376$ ) and research institutes ( $R^2 = .591$ ).

As in the full model, holding a PhD and attending more professional meetings are significantly associated with academic and research institute productivity. In the first regression, for academics only, collaboration is positively and significantly associated with productivity ( $b = .160$ ). Also, academic scientists in the fields of agriculture ( $b = .181$ ), and natural ( $b = .220$ ) sciences publish more at a highly significant rate, while both individual ( $b = .144$ ) and project ( $b = .175$ ) awards are highly significant predictors for academic publication. For research institute scientists (column 3), publications are significantly higher for those in the core ( $b = -.200$ ), in natural science fields ( $b = .374$ ), women ( $b = .126$ ), and those who subscribe to more journals ( $b$

= .165). However, for scientists employed in research institutes, the coefficient for collaboration is not statistically significant. In the previous study in Africa and India, the coefficient for collaboration was significant and negatively associated with productivity for research institute scientists. Not only did collaborative efforts fail to improve productivity for research institute scientists in these developing regions, but also they might have been hindering publication output (Duque et al., 2005). While not as extreme, the Chilean case does distinguish this sectoral difference along the productivity dimension.

The regression analyses in Table 4, while relevant for a general understanding of the relationship between collaboration and productivity, does not adequately represent the contextual or productivity differences among scientists. Therefore, I distinguish between three dependent variables of productivity, foreign, domestic, and web.<sup>3</sup> Table 5 reflects the results of estimating separate models for each research sector in Chile, using the same set of contextual, background and professional controls, as well as collaboration predictors of total productivity. The study adds another independent measure of collaboration, the Number of collaborators in developed countries, to address the influence of this geographic dimension of collaboration on publication. The study also includes a control for English language proficiency to test this factor's influence on the location of publication. Taking Table 5 as a whole, collaboration is significantly associated with publication productivity in all but two models. Publication in foreign journals and on the web is not associated with any measure of collaboration for research institute scientists in Chile (column 2, lines 17-19). Total collaborations, however, are significantly associated with publication in domestic journals for both academic ( $b = .196$ ) and research institute ( $b = .278$ ) scientists. The odds ratio is 1.5 times as great for academic scientists, with

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<sup>3</sup> Publishing a paper on the web is a dichotomous (0,1) measure with 'never having published' as the reference group. In the analysis, a binomial logistic regression is applied to this dependent variable. Table 6 columns 5 and 6 represent the estimated odds ratio for each independent variable.

**TABLE 5**

REGRESSION OF FOREIGN, DOMESTIC, AND WEB PRODUCTIVITY ON CONTEXTUAL, BACKGROUND, PROFESSIONAL, NETWORK, LANGUAGE, AND COLLABORATION

	ARTICLES IN FOREIGN JOURNALS <sup>a</sup>		ARTICLES IN DOMESTIC JOURNALS <sup>a</sup>		WEB PUBLISHING <sup>c</sup>	
	Academic	Research	Academic	Research	Academic	Research
<b>Contextual Factors</b>						
1. Region	N/A	-.176**	N/A	-.162*	N/A	.679
2. Agricultural sciences	.108	-.068	.215**	.447***	.362**	39.432**
3. Physical Sciences	.100	-.021	-.033	.023	.555	2.583
4. Natural Sciences	.188**	.273*	.099	.303*	.392*	23.409**
5. Social Sciences	.016	-.027	.212***	.169*	1.495	21.281
<b>Background &amp; Education</b>						
6. Gender (male)	-.040	-.186***	-.007	.030	.868	1.345
7. Age	-.067	-.015	.104	.046	.966**	1.005
8. PhD	.344**	.274***	.000	.016	1.280	1.669
9. Degree from developed country	-.038	-.141*	.119	-.102	.883	.717
<b>Professional Activities/Awards</b>						
10. Professional meetings attended <sup>a</sup>	.240***	.205****	.115*	.210**	.756	.952
11. Number of journals subscribed to <sup>a</sup>	.021	.224***	.062	.019	1.563**	1.772*
12. Individual awards <sup>a</sup>	.197**	.267***	.038	.159*	1.324	1.483
13. Project awards <sup>a</sup>	.105*	.047	.152**	.157*	.679*	1.111
<b>Language</b>						
14. English proficiency <sup>b</sup>	-.084	-.091	.217***	-.216**	.877	.514**
<b>Networks</b>						
15. Size of domestic network	-.134**	-.141*	.133**	-.003	1.032	1.037
16. Size of international network	.008	.026	-.033	-.084	.958	1.198
<b>Collaboration</b>						
17. Total collaborations (out of 3 main projects)	-.012	-.008	.196**	.278***	1.018	.800
18. Number of collaborators in developing countries	.155**	.045	.000	-.103	1.839**	1.118
19. Intra-organizational Collaboration <sup>a</sup>	-.067	.057	-.009	-.028	1.502*	1.572
20. R <sup>2</sup>	.448	.623	.321	.436	.241 <sup>d</sup>	.456 <sup>d</sup>
21. N	203	122	203	122	203	123

\*\*\*, \*\*, \* significant at the .01, .05, .1 levels respectively.

a. Variable is expressed as a natural logarithmic transformation

b. 1 = very comfortable; 4 not at all comfortable (the direction of the relationship is reversed for the analysis)

c. A binary logistic regression is employed, representing the estimated odds ratio for each independent variable.

d. Nagelkerke R<sup>2</sup>.

more intra-organizational collaborators reporting they had published on the web (column 5, line 19). In addition, the increase of collaborators located in developed countries (column 1, line 14) is highly significant in predicting academics publishing in foreign journals ( $b = .155$ ), as well as ever publishing on the web (odds are 1.8 times as great). The size of domestic network is negatively significant for both sectors publishing in foreign journals (columns 1 and 2, line 15), suggesting that knowing more local professionals actually depresses one's foreign productivity. But the size of domestic network is a highly significant predictor for academic scientists publishing in domestic journals ( $b = .133$ ).

English proficiency is not associated with foreign productivity, but is associated with domestic publications and web publishing. It helps research institute scientists in publishing for domestic journals ( $b = -.216$ ), while in publishing on the web, the odds ratio is 0.50 times less if the research institute scientist is less proficient in English (column 6, line 14). Furthermore, English proficiency depresses the publication rates of academic scientists in domestic journals ( $b = .217$ ).

With the exception of web publishing, what is most consistently significant in predicting productivity across both Chilean sectors is attendance at professional meetings (columns 1-4, line 10). This is similar for the full sample in the previous study in Africa and India, but not consistent across any one region, as in Chile. It is an interesting finding, given the low rate of conference attendance by Chileans scientists compared to other regions, and the ambivalence shown by many of the Chilean scientists interviewed when asked about attending conferences (Duque, 2006). Region of the research sector is significant for research institute scientists across both publication dimensions (columns 2 and 4, line 1). It is advantageous to be close to the core if you work in a research institute. Journal subscriptions favored research institute scientists

publishing in foreign journals ( $b = .224$ ) and on the web (odds are 1.8 times as great), and significantly favored web publishing among academic scientists (odds are 1.7 times as great). Individual awards were significant in predicting foreign publication across sector (columns 1 and 2, line 12), but significantly associated only with research institute scientists publishing in domestic journals ( $b = .159$ ). Project awards are significantly associated with domestic publication across sector (columns 3 and 4, line 13), while it is negatively related to academic scientists reporting if they had ever published on the web (odds are 0.68 times as less).

Gender is significant for research institute scientists publishing in foreign journals (column 2, line 6), favoring females ( $b = -.186$ ). While age played no role in determining traditional publication patterns, youth does benefit academic scientists publishing on the web (odds are 0.97 times as less with each year older).<sup>4</sup> Having a PhD is highly significant across sector only for foreign publications (columns 1 and 2, line 8). Acquiring the degree from a developing country was only significant and negative for research scientists publishing in foreign journals ( $b = -.141$ ).

Considering the effect of field, natural scientists significantly publish more in foreign journals across sector (columns 1 and 2, line 4), while they publish at high rates in domestic journals ( $b = .331$ ) and on the web (odds are 23 times as great) if they work in research institutes. Natural scientists in academic departments, however, publish significantly less on the web (odds are 0.39 times as less). Agricultural and social scientists publish at significantly high rates in domestic journals across sector (columns 3 and 4, lines 2 and 5). Finally, while agricultural scientists in research institutes are much more likely to have reported ever publishing on the web (odds are 39 times as great), they are much less likely to have reported this if they are working in academic departments (odds are 0.36 times as less).

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<sup>4</sup> The negative association of age affect on web publishing in Table 5 is reflected by an odds ratio that is less than 1.

In interpreting these results, it is appropriate to note that in the past study in India and Africa, only Kenyan academic scientists benefited from collaboration across location of publication. In Chile, the pure effect of total collaborations among three present projects is only significant for publishing in domestic journals. There is no benefit to publishing in foreign journals, most often the “gate keepers” for attaining a high impact ISI credit necessary for promotion in the Chilean context. Having more intra-organizational collaborators was significant only for academic scientists in reporting that they had published a paper on the web. Having more collaborators located in developing countries, though, does benefit academic scientists in foreign productivity and in reporting they had ever published a paper on the web. This suggests a network alternative to the often simple dichotomous concept of collaborating, which was not associated with these productivity dimensions in Table 5. In addition, although the number of international contacts (distinguished from foreign collaborators) has no effect on foreign publications, the number of domestic contacts did and was negative. This suggests two interpretations: (1) The greater number of international collaborators a Chilean academic scientist has is more important than the amount of collaborative projects the scientist is involved with in predicting international productivity; and (2) while it is helpful to have more foreign collaborators when publishing internationally, it is just as advantageous to have fewer local professional contacts. Collaboration per se is not the antidote for promotion as much as the location of one’s collaborators and professional contacts.

Another appropriate comparison with the past study is the importance of attending professional meetings. It was only significant for Kenyan academic scientists publishing in foreign journals and for Indian research institute scientists publishing in domestic ones in a past study (Duque et al., 2005). This factor, though, is a consistent and positive predictor across

sector and publication location in the Chilean context. Yet attending professional meetings, especially those in developed countries is not necessarily convenient or affordable when one resides in the southern cone.

Finally, the coefficient of English proficiency in Chile, while not significant with foreign publications, is in the intuitive direction. The lack of a significant relationship in foreign publication, guided by results from the number of collaborators located in developed countries, indicates that the need for English proficiency is not important beyond communicating with international scholars. International collaborators will most likely take on the responsibility of writing, editing and communicating with potential journal outlets in the First World. This has been the experience of the project's earlier collaborations in Africa and India. In general, this may be due to the comparative resources inherent in transnational projects. Most originate in the exterior or within a developed world facility, where institutional pressure to publish is high. When faced with the unique social and professional realities experienced by developing world collaborators, the intellectual division of labor frequently weighs towards relying on the specialist from abroad. Often low wages and limited access to technologies translate into added occupational pressures in the developing context, an environment that seldom permits local researchers either the time or motivation to publish. However, Chileans enjoy higher wages, have superior technological infrastructure relative to other regions, and most importantly have a strong motivation to publish. It is possible this may reduce the dependence on outside agents compared with the more problematic African context. Much of the communication with foreign contacts and collaborators, found significant to the publishing process, is mediated through email. To consider the role the Internet may fulfill in the Chilean context, the next section

considers the relationship between email adoption and practice and reporting problems in conducting collaborative research.

### *Email Use and Problems of Collaboration*

Collaboration translates into higher productivity in some regions, but not in others. Collaboration had larger and more consistent effects in Lee and Bozeman's (2005) sample of U.S. scientists than in the previous samples from Africa and India. The Chilean context, however, is reflective of the U.S. study. Collaboration does have a positive relationship with domestic publication across sector in Chile. The number of collaborators located in developing countries is positively associated with publishing in foreign journals for the sample of academic scientists, while reporting more local contacts is associated with publishing domestically. In general, collaboration is seen as a benefit to projects that employ an intellectual division of labor. The results, in terms of publications for example, are greater than the costs involved in coordination. One interpretation from a previous study suggests that collaboration actually depresses total productivity for scientists in research institutes (Duque et al., 2005). In the African context, the costs seemed to outweigh the benefits: These researchers collaborated most, but published the least. The Indian context was distinct: These researchers collaborated least, yet published the most. The challenges of communicating and coordinating are magnified for researchers in developing regions. This was the project's experience in an earlier transnational collaboration, and it seems to be the case when collaborators are in the same city, whether that city is Santiago, Nairobi, Accra, or Thiruvananthapuram. Where costs of coordinating a project are high, the benefits of collaboration may be limited.

The earlier study argued that in the North the primary technology of collaboration is the Internet and, in particular, communication using email (Duque et al., 2005). While email technology is available globally, local variation in access is great. Most scientists in developed regions enjoy consistent connections and high band width with few exceptions. The previous study confirmed Walsh and Maloney's (2003) study of U.S. scientists to a certain extent, which suggested that access to email reduced problems of coordination in collaboration. Indian scientists had the most consistent access to email and reported the least problems, although the outcome did not necessarily translate into more collaboration. African scientists had the least consistent access to email and reported the most problems in research. Paradoxically, this did not limit the Africans, especially the Kenyans, in their high collaborative behavior. In the Chilean context, consistent access to email is not an issue. But there are differences by sector in terms of email adoption and practice, collaboration, and publication behavior. To test if the use of email attenuates research challenges, I re-addresses this question in the Chilean context to consider individual and institutional differences: Do those who make greater use of email report fewer problems of coordination?

Table 6 presents several measures of problems reported by Chilean scientists. In the previous study in India and Africa, the project asked respondents to indicate the extent to which each of ten issues is a major problem, a minor problem, or not a problem in the current research. In general, the African scientists report more problems, ranging from 'contacting people' and 'coordinating schedules,' to information issues such as 'transmittal' and 'security,' to 'division of work' and 'resolution of conflicts.' By comparison, Chileans report fewer problems 'contacting people' ( $m = 2.54$ )<sup>5</sup> than the full sample of Africans and Indians in the previous

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<sup>5</sup> Problems were measured as 1 = major problem, 2 = minor problem, 3 = no problem. The higher means indicate less of a problem.

study, but report more problems with ‘too much information’ (m = 2.05). This is confirmed in qualitative interviews and may be attributed to greater Internet access and higher bandwidth, in Chile compared to the previous regions studied (Duque, 2006). More access means more

Problems <sup>a</sup>	Academic	Research	Total	N
1. Contacting people	2.51	2.6	2.54	333
2. Coordinating schedules	2.25	2.16	2.21	333
3. Length of time to get things done	1.85	1.87	1.86	333
4. Transmitting information	2.48	2.36	2.43	333
5. Getting others to see point	2.18	2.06	2.13	331
6. Security of information	2.5	2.39	2.46	329
7. Resolving conflicts	2.37***	2.17	2.3	331
8. Dividing work	2.43	2.34	2.4	332
9. Keeping others informed of progress	2.56	2.46	2.52	331
10. Too much information	2.08	2.01	2.05	331

\*\*\*, \*\*, \* significant at the .01, .05, .1 levels respectively  
 Significant differences reflect a one-way Anova means comparison test.  
 a. 1=a major problem, 2=minor problem, 3=no problem

meaningless information is disseminated. Across Chilean sectors, research institute scientists generally report more intensity across all problem dimensions. The only significant difference, however, is with ‘resolving conflicts’ (Table 6, line 7). Respondents in Chilean research institutes reported this as a problem at a significantly more intense degree than those in academic departments. This institutional distinction may be attributed to the independence enjoyed by

academic researchers, while the inter-dependent research institute setting can often lead to disagreements over resource distribution and division of labor.

How is collaboration related to reported problems in Chile? The previous study distinguished between those who reported one or more collaborations and those who reported none. In each case, African and Indian scientists who reported one or more project collaborations were significantly more likely to report problems than those who did not collaborate. Collaboration did translate into more research problems in these regions. Yet collaboration alone is not the only dimension that complicates research. The total number and distinct location of collaborators can magnify research difficulties as well. Unlike the previous study, I asked Chilean scientists to report the number of collaborators over three current projects by geographic location. An ordinal scale of collaboration was recoded from this original measure of collaboration: none, one to three, four to seven, and eight or more. I was able to distinguish between those in the sample with exclusively Chilean collaborators and those with a mix of collaborators within and outside Chile, or an indication of the homogeneity of collaboration network. Though there were significant differences in every problem variable in the previous study, the study focuses on six variables with significant differences among Chilean scientists: ‘coordinating schedules,’ ‘length of time to get things done,’ ‘transmitting information,’ ‘resolving conflicts,’ ‘dividing work,’ and ‘too much information.’ Table 7 provides the results of a one-way Anova multiple comparison test for six dimensions of research problems in the Chilean context for comparison. In the one overlapping problem dimension with the past study, Chileans scientist who had no collaborators report much less intense problems in ‘transferring information’ ( $m = 2.74$ ) than the Indians and the Africans with no collaborations.<sup>6</sup>

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<sup>6</sup> Number of collaborative projects (0-3) out of three current projects was the measure used in analyzing the Indian and African data, while number of collaborators over three current projects is used in this present analysis. Since

Moreover, those Chileans with eight or more collaborators report this problem with the same intensity as those African and Indians with no collaborations (m = 2.30). Clearly, some problems are not issues in Chile as they are in other regions. Within Chile, however, there

**TABLE 7**

**MEAN OF SELF-REPORTED RESEARCH PROBLEMS AND COLLABORATION**

<b>Problem<sup>1</sup></b>	<b>Number of collaborators</b>				<b>Homogeneity of collaboration network</b>	
	<b>None<sup>a</sup></b> (N = 26)	<b>1-3<sup>b</sup></b> (N = 177)	<b>4-7<sup>c</sup></b> (N = 108)	<b>8 or more<sup>d</sup></b> (N = 23)	<b>All in Chile</b> (N = 153)	<b>Mixed</b> (N = 155)
1. Coordinating schedules	2.38	2.28	2.07 <sup>ab**</sup>	2.13	2.30 <sup>**</sup>	2.13
2. Length of time to get things done	2.08	1.90	1.71 <sup>ab**</sup>	1.96	1.93	1.80
3. Transmitting information	2.73	2.50	2.28 <sup>ab***</sup>	2.30	2.49	2.38
4. Resolving conflicts	2.69 <sup>bcd***</sup>	2.31	2.20	2.17	2.34	2.26
5. Dividing work	2.42	2.48 <sup>d***</sup>	2.25	2.39	2.48 <sup>**</sup>	2.32
6. Too much information	2.19	2.13	2.01	1.57 <sup>abc***</sup>	2.11	2.01

Significant differences reflect a one-way Anova LSD post ad hoc means comparison test  
 \*\*\*, \*\*, \* significant at the .01, .05, .1 levels respectively  
 1.. 'Research problems' coded as: 1=a major problem, 2=minor problem, 3=no problem

is a significant increase in intensity of reported problems as scientists report more collaborators.

Those with 4 to 7 collaborators report significantly more problems than those with 1 to 3

collaborators or no collaborators (lines 1-3) for 'coordinating schedules,' 'length of time to get things done,' and 'transmitting information.' Having no collaborators is significantly related

with less intensely reporting problems for 'resolving conflicts' (line 4). Those with 1-3

collaborators report significantly less intensely problems than those with 8 or more collaborators

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reporting no collaborative projects in the Indian and African context is the same as reporting no collaborators in the Chilean context, this limited comparison is feasible.

for ‘dividing work’ (line 5). Finally, those with 8 or more collaborators report significantly more intensely problems than all other categories for ‘too much information.’

Columns 5 and 6 in Table 7 distinguish between the homogeneity of a Chilean scientist’s collaborative network. In every category of problem, those with exclusively Chilean collaborators report less intensity. Only two of six dimensions reveal significant differences, however. Having exclusively Chilean collaborators significantly reduces the intensity of reported problems in ‘coordinating schedules’ and ‘dividing work.’ These general findings can be attributed to the benefits of culture, language and geographical proximity within country collaborative relationships. This confirms to a certain extent the negative results of heterogeneous networks suggested in the literature (Rothschild-Whitt, 1979; Sirianni, 1994; Huang, 2006). The issue remains whether these reported indices of problems in collaboration are purely a result of the number and location of collaborators with which Chilean scientists work, or the intensity and diversity with which they employ Internet technologies in their work.

Chileans report email access at over 99 percent, positioning them as the leader in connectivity among the regions represented to this point in the study. This is due to concerted efforts to upgrade connectivity among research institutes and universities during the dictatorship of the mid 1980s. Unlike the previous study in Africa and India, the question is moot as to whether Chilean scientists with access to email report fewer problems of collaboration, controlling for other factors; Chileans have ready access. For the following analysis then, I employ three independent Internet dimensions that distinguish Chileans scientists: email age, hours using email, and email use diversity.

Table 8 reflects the results of twelve multivariate regression models, two for each of the six research problems distinguished as variable in the Chilean data. I test these by using many of

the control variables presented in Table 5: region, sector, field, gender, age, and English proficiency. Then I add the number of projects directed as an additional control, since this administrative dimension may distinguish a researcher's likelihood to report more intensely problems. The even numbered models include only collaboration and email variables. The odd numbered models include important controls to test if there is any significance of the initial collaboration and email variables. I was able to account for the numbers of collaborators by region over three current projects, thus the study uses the continuous additive variable, total collaborators (range from 0 to 15). Since this variable is positively skewed, it is expressed in a natural logarithmic transformation in the analyses. I also control for the homogeneity of collaboration network, a dichotomous measure that indicates if a scientist's collaborators are exclusively Chilean or not. In the previous study of African and Indian scientists, total collaborations among three current projects and email access were significantly associated with four research problems tested: 'contacting people,' 'transmitting information,' 'security of information,' and 'keeping people informed of progress.' Collaboration consistently predicted more intense reports of these problems, while email access consistently predicted less intense reports. Considering the Chilean context in Table 8, total collaborators is the only consistent and significant predictor of reporting more intensely in five out of six problems tested (line 3): 'coordinating schedules' ( $b = -.114$ ), 'length of time getting things done' ( $b = -.140$ ), 'transmitting information' ( $b = -.225$ ), 'resolving conflicts' ( $b = -.226$ ), and 'too much information' ( $b = -.143$ ). Since higher values on problem variables represent fewer research problems,<sup>7</sup> the negative coefficients indicate more intense reporting of problems associated with more reported collaborators. Having an exclusively Chilean collaborative network is significant,

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<sup>7</sup> That is, a code of '1' represents a 'major problem'; '2' represents a 'minor problem'; '3' is used for 'not a problem'.

**TABLE 8**

REGRESSION OF PROBLEMS IN RESEARCH<sup>a</sup> ON EMAIL PRACTICE, COLLABORATORS, CONTEXT, BACKGROUND, PROJECTS, AND LANGUAGE

	Coordinating Schedules		Length of Time Getting Things Done		Transmitting Information		Resolving Conflict		Dividing Work		Too much Information	
	1	2	3	4	5	6	7	8	9	10	11	12
<b>Internet Factors</b>												
1. Hours using email	-.056	-.049	-.055	-.053	-.036	-.032	.011	-.001	-.104**	-.093	.005	-.018
2. Email diversity	-.015	-.059	.029	.026	.053	.021	.006	-.032	.019	.021	-.081	-.131**
<b>Collaboration</b>												
3 Total collaborators <sup>b</sup>	-.114**	-.089	-.140**	-.124**	-.225***	-.196***	-.226***	-.176***	-.089	-.080	-.143***	-.108*
4. Homogeneity of collaboration network	.085	.115**	.058	.059	.038	.060	.016	.032	.096**	.096	.018	.040
<b>Contextual Factors</b>												
5. Region		.099*		.099*		.091		-.037		.007		-.036
6. Sector		.034		.088		-.064		-.083		-.017		.055
7. Agricultural sciences		.066		-.072		.019		.029		.089		-.059
8. Physical Sciences		.153**		.015		.026		.089		.052		.036
9. Natural Sciences		.089		-.100		.127		.017		.044		.003
10. Social Sciences		.059		-.182***		-.103		-.031		.060		.117*
<b>Background</b>												
11. Gender (male)		-.009		.051		-.032		.023				.074
12. Age		.142**		.165***		.015		.006		.068		.034
<b>Projects</b>												
13. Projects directed		-.128**		-.101*		-.106*		-.008		-.046		-.089
<b>Language</b>												
14. English Proficiency		-.156***		-.013		-.091		-.096		.022		-.129**
15. R <sup>2</sup>	.031	.098	.029	.094	.054	.114	.040	.078	.033	.049	.034	.075
16. N	332	328	332	328	332	328	330	326	331	327	330	326

Note: \*\*\*, \*\*, \* significant at the .01, .05, .1 levels respectively.

a. 1=a major problem, 2=problem, 3=no problem; negative coefficients indicate greater problems.

b. Independent variable is expressed in a natural logarithmic transformation.

in only model 9, 'dividing work' ( $b = .096$ ). It is a positive relationship, which indicates that homogenous collaborative networks ease the intensity of reporting problems along this one dimension. However, an email variable is significant in only one model. Hours using email is significantly associated in Model 9 'dividing work' ( $b = -.104$ ). The coefficient is negative indicating that more email use is associated with reporting more intensely along this particular problems dimension. This outcome is in contrast to the previous study in Africa and India, where email access was linked to reporting less intense problems in research. This suggests that technology use in Chile, far from having an ameliorating effect on the research process, may at best respond to pressures in research and at worst, result in more difficulties. This is similar to the interpretation of the African case, where it was posited that Kenyans may be employing the Internet to take on more projects and remote collaborators, thus magnifying the challenges in collaborative research they already experience (Duque et al., 2005).

The final series of models are reported in columns two, four, six, eight, ten and twelve of Table 8. The difference between these six models and simpler counterparts was the inclusion of controls for sectoral, regional, and field contexts, background, project administration, and English proficiency. What emerged in the past study with more complex models is that the coefficients for collaboration were no longer statistically insignificant. The reduction in impact was primarily attributable to effect of developmental region—Kenyans significantly reported more problems than the other two regions studied. In the Chilean context, however, collaboration variables remained significant in four of the original six problem dimensions. In each case for total collaborators the coefficient is reduced, but remains significant: 'length of time getting

things done' ( $b = -.124$ ), 'transmitting information' ( $b = -.196$ ), 'resolving conflicts' ( $b = -.176$ ), and 'too much information' ( $b = -.108$ ). Having only Chilean collaborators is no longer significant in Model 10 'dividing work,' but emerges significant in Model 2, 'coordinating schedules' ( $b = .115$ ) when controls are added. While email variables were stable and positive in the African and Indian study, the only email variable found significant in the Chilean context, hours using email (Model 9) is no longer related when controls are included. Yet, email diversity emerged significantly associated in Model 12 'too much information' ( $b = -1.31$ ), when controls were included. Again the coefficient was negative, indicating that with more email practice, Chilean scientists significantly report more intense problems in research along this dimension.

In Chile, region ( $b = .099$ ), the field of physical science ( $b = .153$ ), age ( $b = -.142$ ), projects directed ( $b = -.128$ ), and English proficiency ( $b = -.156$ ) cancelled the significance of collaboration in only one model in which these dimensions were originally not accounted for, 'coordinating schedules.' Region was also marginally significant for 'length of time getting things done' ( $b = .099$ ), as was the field of social sciences ( $b = -.182$ ), age ( $b = .142$ ), projects directed ( $b = -.128$ ), and English ( $b = -.156$ ). English was also significant and negative for 'too much information' ( $b = -.129$ ). The negative coefficient indicates that Chilean scientists who are more comfortable communicating in English report less intensity in coordinating schedules and managing too much information.

## **Conclusion**

The Chilean context distinguished itself from the previous settings of the study. Compared to the Indians and Africans, Chileans scientists enjoy consistent and widespread Internet access, report fewer problems in their research, collaborate with more frequency, and publish at twice the rate in foreign journals as do the Indians and the Africans. There is no paradoxical relationship (Duque et al., 2005) between collaboration and productivity. Collaboration is associated with more productivity in Chile as in the U.S. case (Lee and Bozeman, 2005). The number of collaborations over three current projects is a significant predictor of publishing in domestic journals across Chilean sectors, while the number of collaborators in developed countries is associated with more foreign productivity for academic scientists. In addition, reporting more intra-organizational and developed country collaborators results in a greater odds ratio of publishing on the web for the sample of academic scientists.

The recent Millennium Science Initiative (MSI) that sought to increase the international links among Chilean researchers (Holm-Nielsen and Agapitova, 2002) may explain this positive collaboration-publication relationship, especially productivity in foreign journals. NSF data, meanwhile, suggested that international collaboration is the primary reason for the sharp rise in Latin American co-authored publications (Hill, 2004). The Chilean case indicates that promoting an outward orientation in professional links translates into increased domestic, foreign, and web productivity in this region.

However, there are variations in productivity within Chile across contextual and background factors. Some of these confirm, while others contradict, findings in the literature. For instance, Mullin et al. (2000) suggested an urban or core bias in resource

flows in Chile, and the literature consistently contends a publication and citation bias favoring the global science core (Merton 1968; Cole and Cole, 1973; Cozzens, 1990; Moody, 2004). The Chilean data responds affirmatively to these suggestions. Scientists in research institutes located in the regional core of Santiago publish significantly more in both domestic and foreign journals, when controlling for other factors. Gender has an interesting effect in the research institute sector. Women significantly publish more in foreign journals, suggesting an institutional flexibility in this sector, compared to possible inertial traditions of the academy (Raina, 1999). Age, one of the preeminent predictors of scientific productivity, has an influence only for publishing on the web. Older academic scientists are more likely to report this high-tech behavior, contradicting diffusion of innovations arguments (Rogers, 1995) that suggest age is inversely related with technology adoption. This view can also be attributed to the low credit received for web publishing relative to high impact ISI publications. Tenured scientists may not have the same urgency to have every publication count, as do younger researchers working up the scientific ladder.

English proficiency has positive impact for research institute scientists publishing in domestic journals, but is negatively associated when these same scientists publish on the web. It is also negatively associated when academic scientists publish domestically. These confounding findings (1) suggest an institutional variation in the importance of English proficiency within Chile; and (2) contradict the English bias associated with the Internet. If a researcher has a facility for English, the Chilean academic scientists may opt to pursue publications in foreign English language journals (which more likely than not hold greater ISI impact), at the expense of publishing in domestic or web based

outlets. Just as interesting, the size of domestic networks has a depressing affect on foreign productivity. If a researcher should report more domestic contacts, the Chilean scientist across sector may pursue domestic publications at the expense of foreign ones. Supporting this last finding is the fact that having more domestic contacts is significantly associated with publishing in domestic journals for the sample of academic scientists. Language proficiency and location of contacts emerge as possible intervening factors that may be structuring the location of publication, the combined effects of which are indeterminate in terms of elixir or affliction outcomes.

How the Internet mediates problems in collaboration among Chilean researchers was the second dimension addressed in this chapter. Chileans on the whole report fewer problems in research compared to past developing region studies. Similar to past studies (Duque et al., 2005), Chileans do report more intensely the problems in research when reporting more collaborators. Chileans also report more intense problems when their collaborative network is heterogeneous, confirming the suggestion of past research (Huang, 2006). Unlike past study though, when controlling for other factors, collaboration measures in the Chilean context continue to be significantly associated with reporting more intense problems in research.

In the previous study in Africa and India (Duque et al., 2005), access to email was the measure used to identify variations among researchers' collaborative behavior and the problems reported in research. Since adoption and access are widespread in Chile, the 'hours using email' and 'email use diversity' were substituted as Internet measures my analysis. Yet unlike other regions, Internet factors were not significantly associated with reporting fewer problems in research. Further, when controlling for only collaboration,

more 'hours using email' was actually significantly associated with reporting more intense problems 'dividing work' in research. When controlling for contextual and background variables, this negative association disappeared. Yet 'email diversity' emerged as significantly associated with reporting more intense problems with 'security of information'. It may not be that email use is creating problems, but it is associated with the problems encountered when collaborating more. Perhaps as in Africa, Internet use may be in response to increased collaboration, which in turn is associated with more problems—a weak indication of affliction.

It is important to keep in mind that even though Chileans collaborate at similar high rates compared to the Africans, Chileans do not report problems in research at the same high intensity levels. Furthermore, as past research suggests regarding Internet access and use, the intensity and perhaps the benefits of Internet use tend to level with experience (Wellman and Haythornthwaite, 2003). In the case of Chile, which enjoys the longest and most complete Internet access of the regions studied, the benefits of the Internet in reducing difficulties in research have most likely reached a plateau. The Africans of the previous study have yet to reach that same plateau, given the inconsistency of Internet access. In some cases, Internet infrastructure is worse for Africans than five years ago.

The policy suggestion from this study leans toward promoting collaboration and Internet diffusion throughout Latin America. This though would be short sighted if not considered within the context of the Chilean case. Chile has in place many of the rational endogenous systems found in developed nations: democratic forms of governance, a free market economy, reliable legal systems, comprehensive Internet infrastructure, stable

growth, and strong regional and global economic ties. These systems some would argue came at a great social cost. Chile's experience in this sense is unique and not homogenous with other nations in the region, especially those with low economic performance and those that lack knowledge and communication infrastructures that can compete on a global scale. Thus, caution should be considered when taking a "one size fits all" policy mentality in this region.

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