2007

How the internet is shaping the Chilean scientific community: globalization and dependency

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HOW THE INTERNET IS SHAPING THE CHILEAN SCIENTIFIC COMMUNITY: GLOBALIZATION AND DEPENDENCY

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agriculture and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Sociology

by
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May 2007

ACKNOWLEDGMENT

First, I would like thank my mother, Eliana Becker Duque M.A., and my father, Dr. Fernando Duque. Without their life long guidance and specifically their assistance in bringing my research to their nation of origin, Chile, this dissertation could not have been possible. I truly am my parent's son. I would also like to thank my family in Chile located in Santiago, Concepcion, and Chillan, whose support and networks helped facilitate this research. The collaboration of graduate colleagues, Dr. Marcus Ynalvez, Meredith Anderson M.A., and Paige Miller M.A., has been very much needed and appreciated. Friends and colleagues Camille Manning M.A., Susan Arnold M.A., and Maria Cazes M.A. were important sources of encouragement and support over the past six years. My World Science Project collaborators, Dr. R. Sooryamoorthy (South Africa), Dr. Paul Mbatia (Kenya), Dr. Dan-Bright Dzorgbo (Ghana), and Dr. Antoni Palackal (Kerala), provided invaluable mentorship and friendship. My Chilean collaborators and their graduate students in the departments of sociology at the University of Concepcion and Universidad Catolica, Dr. Omar Bariga, Guillermo, Henriquez M.A., and Marjorie Murray M.A., were instrumental in executing both the video and survey portions of the investigation. Their unique stories mapping forty years of Chilean sociology is the inspiration for a documentary film based on this research. My dissertation committee members, Dr. William Bankston, Dr. Jack Beggs, Dr. Mark Schafer, and Dr. Jay Edwards, were helpful in theoretically and methodologically focusing my study. Also, sociology department chair Dr. Michael Grimes and administrator Tonya Duthu provided valuable logistical and moral support. Editors Susan Sarnataro and Lisa Ladwig M.A. contributed to this dissertation's integrity and clarity. Finally, I would especially like to thank the chair of my doctoral committee, my mentor and friend, Dr. Wesley Shrum. This has been an adventure of the mind and body that has unfolded over six

years and spanned four continents. It was good to have a seasoned captain at the helm. His example will forever inspire me.

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ABSTRACT

The Internet has emerged as a catalyst for global knowledge production. This is supported by its positive impacts in the First World. A progressive assessment argues that the Internet will be the “elixir” that brings immediate visibility and relevance to scientific communities in the periphery. Yet, Internet diffusion is often framed by past technology failures that further widen global divides. This characterizes an “affliction” argument. The “teething argument” suggests that adoption within the Third World is tentative at best with benefits unfolding over time in some regions but not others.

This dissertation is a qualitative and quantitative study that tests these three technology arguments (elixir, affliction, and teething) in a Latin American region. It considers the relationship between scientific communication, collaboration, and productivity in Chilean science, focusing on the role of Internet practice. Results are presented through the qualitative analysis of 29 video taped interviews, followed by a quantitative analysis of a communication network survey administered to 337 Chilean researchers.

Qualitative findings suggest that despite Chilean regional leadership in economic output, political disruptions and a paucity of local resources motivate many researchers to seek training abroad. This creates new, exterior contacts that are maintained through email communication. These cyber links, though, may also be creating technology dependencies. Quantitative results confirm that Chilean scientists are well connected when compared to past region studies. Yet, the Chilean scientific community reports an inverse relationship between domestic and foreign contacts, mirroring the disjointed network profile found in other developing regions. Other 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 publications. Although Chileans seldom report problems, those they do report are associated with working with more collaborators and having geographically heterogeneous networks. Email shows no effect toward reducing research problems; and in some cases, email is associated with more intensive reports of problems. Taken as a whole, this author's findings support a "teething" argument for Internet influence on professional networks and activities within the Chilean scientific community.

INTRODUCTION

In June of 2004, this author spent one month in Chile, interviewing a variety of local scholars, many of whom had received their advanced degrees in developed countries. One scholar is a respected associate professor at a prestigious research university, originally patterned after the University of California at Berkeley.[1] Chilean born, but raised and trained in the United States, he returned home to pursue a professional academic career. Yet, for the better part of the first decade of his career in Chile, this scholar was unable to conduct any meaningful research. Instead, he and his colleagues were reconstructing the discipline of sociology that only 16 years earlier did not exist in his institution.

The field of sociology is one of many ideological victims of the 1973 neo-liberal military overthrow that fundamentally changed Chile.[2] This over-throw is often referred to by locals as simply *el golpe*. The dictatorship that followed eliminated numerous departments of social sciences throughout Chile, and systematically liquidated, displaced, or exiled many scientists and academics. The result was a tragic loss of intellectual capacity and autonomy for the national research community over the next two decades. Yet this type of disruption is not unique just to Chile. In the last half century, this story has often been repeated throughout the developing world, representing a cornerstone of the Sisyphean challenge facing scientific communities located in these regions (Sagasti et al. 2003).[3] Aside from political disruptions, other obstacles include resistant local cultures, the lack of resources, inconsistent science and technology policy,

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[1] The adoption of northern university structures and curricula is well documented in Chile (Brunner, 1985). It is also supported by my video interviews conducted with Chilean researchers in June 2004.

[2] The 1973 military overthrow signified a shift from the interventionist economic model implanted by the former Marxist government to a free market model implanted during the Pinochet dictatorship (Kerbo, 1978).

[3] The Sisyphus Challenge (Sagasti et al., 2003) refers to the insurmountable process of developing an endogenous or locally integrated scientific community in the developing world. Historical and global forces have created dependent, or exogenous, scientific communities in these regions with little local relevance or capacity for globally competitiveness.

and external market forces that limit how periphery regions can nurture and develop the endogenous science and technology environments, which characterizes much of the First World.

Chile is an interesting case study. It is often referred to as a shining example of global development, even though for most of its history Chile has experienced strong dependency upon the economies of the Northern hemisphere. As one local scholar put it, “Everything in Chile comes from abroad.” Chile’s scientific community, like many in the developing world, has been characterized as being isolated and with low productivity. The 1973 military overthrow may have added to these limitations by further entrenching dependency patterns.[4] The possible factors include: (1) research funding deficiencies in the years following the *golpe*; (2) loss of international collaborative ties, resulting from universal displeasure over the military take-over; (3) whole disciplines and research programs, viewed as a threat to the new regime, removed from university rosters; and (4) the partial Diaspora—brain drain—of its scientists, many of which were forced into exile or departed Chile for better funding opportunities and prestige in the exterior.[5] Yet while some lost, women found new roles in Chilean sciences during the dictatorship. They have since lost ground, though.

Since the end of the Pinochet dictatorship in 1989 (marking the beginning of a new democratic era), many exiled and displaced scholars have found their way back to Chile to help rebuild a marginalized scientific community. Surprisingly, despite inadequate research facilities, this group of scholars encountered a strong policy commitment from the national government and the international scientific community in support of developing a competitive research base. At present, the Chilean National Council for Science and Technology (CONICYT) targets

[4] It takes decades to develop a successful scientific program in the developing world. It only takes a fraction of the time to destroy it (Sagasti et al., 2003).
[5] Zuckerman (1996) describes a similar dynamic in Nazi Germany, suggesting that political turmoil results in the scientific Diaspora of a nation’s best and brightest.

research funding that promotes developmental gains fueled by three decades of free market restructuring. The international emphasis, led by the World Bank and several international research institutes, seeks to integrate Chilean scholarship into a global scientific community. However, it has not been easy to gain an advantage where resources are scarce, professional networks are uncoordinated, and institutions are pre-occupied with the reconstruction of curriculum.

The Internet is a development project from abroad—another kind of *golpe* —similar to the democracy and neo-liberalism programs that preceded it. The positive outcomes of Internet adoption in the North (DiMaggio et al. 2000; Castells, 2000) suggest this technology may serve to elevate the Chilean scientific community in the reconstruction process since the end of the dictatorship. The superior information gathering and networking capabilities made possible by Internet technologies presume three positive science outcomes: (1) more symmetrical distributions of knowledge resources across demographic, specifically gender (Palackal et al., 2006), and contextual characteristics (Castells, 2000;); (2) the increased frequency and geographical reach of collaboration (Sproull and Kiesler, 1991; Wellman et al., 1996; Walsh and Bayma, 1996), and (3) a presumed increase of scientific productivity (Duque et al., 2005). Because Chile is a regional leader in economic performance and Internet access, it is often taken for granted that this cyber-optimism will be fulfilled. Moreover, by elevating its global presence, Chilean science may propel national economic productivity, and perhaps allow the greater society to break free of dependency patterns. This is a classical modernization argument that theoretically links the growth of scientific capacity with a nation's development, though so far there are few developing world examples (Shrum and Shenhav, 1997; Sagasti et al., 2003). The present study empirically investigates this cyber-optimism with reference to increasing science capacity in Chile, while shedding light on whether progressive national development may be feasible.

In order to accomplish these research goals, this study considers the relationship between scientific communication networks, collaboration, and productivity in Chilean science, focusing on the role of Internet practice. The Internet is suggested to increase the number and frequency of domestic and foreign contacts among scientists, a main conduit for resources, support, and new ideas (Wellman et al., 1996). This is of particular relevance to scientific communities located in developing regions, since past studies suggest these communities are often isolated (Guillard, 1991), enjoying few contacts in the exterior, while cultural constraints often further disadvantage women scientists in these areas (Palackal et al., 2006). Another suggestions is that such communities are disjointed or uncoordinated, meaning that often developing world scientists within a given community are either globally well-connected or locally well-connected, with few ties between them (Shrum and Campion, 2000). This may be a consequence of impoverished areas, where social and sector networks are often uncoordinated (Sagasti et al., 2003). It could also explain the continued dependency on foreign agents (Shrum, 2005).

Furthermore, prior work based primarily on African data identified a set of issues involving collaboration, productivity, and Internet use in the developing world. Our project team has termed this phenomenon the "collaboration paradox;" in resource-poor contexts, the high costs of collaboration may be greater than benefits in terms of output (Duque et al., 2005). As already mentioned, the Internet is promoted as a technology that will increase both collaboration and productivity. For this reason it is viewed as a type of "elixir" for scientific communities located in developing regions (Davidson et al., 2003; Sooryamoorthy et al., 2007). Though recent findings contradict this notion, it is not known whether these are conditions peculiar to sub-Saharan Africa, or whether the findings are true more generally. This present study provides a comparative case with a distinct historical and social profile as those found in past regions studied.

This investigation is the first to consider the ICT infrastructure, network profiles, and professional activities of a Latin American research community within a global scientific and developmental context. In doing so, the study addresses theoretical issues in science and technology studies, the institutionalization of global science, and the diffusion of technology. In addition, the study incorporates the emerging perspective of "reagency" (Shrum, 2005) into existing historical and comparative perspectives on development. The investigation also focuses on changing social network constraints, resulting from the adoption of new communication and information technologies. The core research questions guiding the study are: 1) What social forces shaped Internet practices within the Chilean scientific community? 2) How is the Internet associated with local and global networks of Chilean scientists? 3) Is the relationship between collaboration and productivity mediated through Internet practice?

Guided by these research questions and the various perspectives outlined, this study evaluates three possible influences the Internet may have on developing world science: the *elixir, affliction,* and *teething* outcomes. Generally reflective of progressive or modernization claims, the "elixir" outcome can be concluded if the Internet is associated with (a) larger networks, symmetrically distributed across social and contextual characteristics, (b) more scientific activity, symmetrically distributed across social and contextual characteristics, and (c) less problems reported in research. Generally reflective of dependency or world systems orientations, a clear "affliction" outcome can be concluded if the Internet is associated with (a) larger foreign networks, asymmetrically distributed across social and contextual characteristics,

(b) less scientific activity, asymmetrically distributed across social and contextual characteristics, and (c) more problems reported in research. Generally reflective of globalization, "teething" refers to a process over time where initially internationally oriented scientific activity and networks gain momentum, with eventual increases in domestic scientific activity and networks. If there is no symmetrical balance over time, the pattern could suggest continued dependency, or an affliction outcome, where domestic activity and networks are permanently eclipsed by global orientations. For this investigation, a "teething" outcome can be concluded if Internet practice is associated with (a) larger foreign networks with an indeterminate symmetry across social and contextual characteristics, (b) more globally-oriented scientific activity with an indeterminate symmetry across social and contextual characteristics, and (c) more problems in research

This investigation is based on a dual research design: a video-ethnography coupled with a comprehensive communication network survey. The video-ethnography of the Chilean scientific community began with the collection of visual audio data in three Chilean regions in June of 2004. It was continued in the spring of 2005 and completed with a recent visit in June 2006. This phase involved semi-structured interviews with 29 Chilean researchers and also included candid interactions among the U.S. and Chilean project members before, during, and after various research visits. The qualitative phase was followed up in the spring of 2005 and the summer of 2006, with a comprehensive communication network survey administered to 337 Chilean researchers. The respondents were selected from a population of university departments in one region and research institutes in three regions.

The questionnaire is based on an instrument previously tested in five countries covering professional background, collaborative projects and productivity, personal and organizational networks, and Internet access and use. To address the ethical issues of conducting cross-national social science research,[6] the project collaborated with local social scientists at the University of Concepcion, University of Los Lagos, Puerto Montt and la Universidad Catolica in Santiago, Chile. The intellectual significance of this project is its empirical focus on an under-researched Latin American community and its contribution to a theoretical and methodological elaboration of the study of science and development. The study provides a broader impact to our understanding of the risks and potentials associated with the Internet and global knowledge production. The dissemination of results through articles and video presentations will aid organizational decision-makers and policy analysts in assessing the extent to which the current policy of promoting Internet adoption and collaboration actually increases scholarly productivity.

In chapter one, this author outlines how science and technology, development and social networks perspectives best frame an inquiry of how the Internet is shaping the Chilean scientific community. Chapter Two reviews the unique Chilean context. In Chapter Three, the study elaborates on the sampling frame and dual methodologies employed. In Chapter Four, qualitative analyses and findings from the video-ethnography are presented, identifying those social forces that shape Internet practice within the Chilean scientific community. In Chapter Five, this author presents quantitative measures, analyses and findings from the communication network survey that explain the relationship between Internet practice and professional networks in Chilean science. In Chapter Six, quantitative measures, analyses and findings from the communication network survey are presented, which explain the relationships between scientific

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[6] This study is framed by the 1964 U.S. Defense Department funded Project Camelot, an ambitious sociological investigation of the entire Chilean society to measure its capacity for revolution. The project failed to get authorization from the Chilean government, and did not acquire solid collaborative links with local scholars and was subsequently terminated (Horowitz, 1967). Many charge though, results were achieved by other means, including CIA sponsored dissertations and through Peace Corp volunteers. Given the socio-political upheaval that occurred in Chile less than a decade after, the scholarly world recognized the sensitive nature of projects from abroad conducting social research within less developed regions (Solovey, 2001). My experience studying the Chilean scientific community over the past two years is informed by the legacy of both Project Camelot and the Chilean dictatorship that followed.

collaboration, publication, and how Internet practice is related to reporting problems in research. The author completes this dissertation with a discussion that synthesizes the findings and extrapolates broader conclusions. These will reflect upon the theoretical frameworks employed and address issues in science and technology, as well as development policy.

CHAPTER ONE: RELEVANT LITERATURE AND RESEARCH QUESTIONS

Increases in geopolitical and environmental disruptions, coupled with a sharp rise in economic growth over the past half century, served to transform knowledge production into a transnational and multi-cultural global activity (Leydesdorf and Etzkowitz, 1998; Nowotny, et al., 2001; Sagasti et al., 2003). Some suggest that technological innovations in transportation, together with information and communication technologies (ICTs) over the last quarter-century, have augmented this trend, while reshaping local-global interactions (Castells, 2000; Robinson, 2003). To comprehend these new spatial and temporal relationships in knowledge production and their consequences, some suggest research should focus on the nature and functioning of scientific institutions (Stehr, 2000; Sagasti et al., 2003). Previous research on scientific communities within the First World suggests a stratification of resources, technologies, productivity, and prestige along demographic and field dimensions (Crane, 1971; Cole and Cole, 1973). The organization of science within the Third World has not garnered as much attention. Yet researchers agree it is a distinct domain, where interaction and outcomes are associated with a complexity of historical postcolonial trajectories. Further, these trajectories are combined with external structural and internal cultural dimensions (Gaillard, 1991; Shrum, 1997; Sagasti et al., 2003). The Internet is predicted to reshape interactions and outcomes in the scientific communities within and among regions of various developmental spheres.

My three research questions pertain to the global diffusion of Internet technologies, most of which originate within the scientific community of the developed world (Abbate, 2000). Internet influence in the United States and Western Europe resulted in the growth, geographic dispersion, and heterogeneity of collaborative groups (Sproull and Kiesler, 1991; Wellman et al., 1996; Walsh and Bayma, 1996). The Internet has also enabled rapid and continuous access to information and shared databases, enhancing real time opportunities to share findings and support the exchange of ideas within the scientific community (Davidson et al., 2003; Sagasti et al., 2003). These seemingly universal benefits have led some to argue that en mass Internet diffusion within the developing world will lead to the globalization of science. This may be an understatement, since modern science is inherently global—abstractly and geographically (Polanyi, 1969; Pyenson, 1985; Chambers and Gillespie, 2000; Sagasti et al., 2003). The optimism of a new world science order predicated on Internet use suggests a symmetrical balance among world spheres of differing economic and political influence that some argue never existed in the modern era (Sagasti et al., 2003). Moreover, some contend the Internet will facilitate (1) local social integration within often internally distrustful and fractured developing regions, (2) universal participation in often elitist-driven and dependent settings (DiMaggio et al., 2001; Castells, 2000; Uimonen, 2001), and, more pertinent to this study, (3) the global visibility of developing world scientists, or the elixir argument (Davidson et al., 2003).

Espousing the "affliction argument," other scholars are skeptical about the positive impacts of the Internet in developing regions (Escobar, 1995; Hedley, 1999; Engelhard, 1999). These researchers aver that new ICTs, like the Internet, may accelerate social stratification among developmental spheres, due to the manner in which these technologies are created, innovated, and sustained. They are designed to benefit the core (the First World and their Third World agents) at the expense of periphery populations.

A final outcome, teething, is a pragmatic prediction, suggesting that some developing world scientific communities may become involved in tutorial relationships with core knowledge institutions. At first, these relationships might benefit the productivity and prestige of the core, but over time these same relationships will transfer valuable scripts, techniques, knowledge, networks, capabilities to increase productivity, and prestige to some periphery regions but perhaps not others.

Whatever the outcome, these professional dynamics will be translated through individual and organizational networks that extend into the exterior. These networks often represent the only avenues for advanced training, collaboration, and publications available to scientific communities located in developing areas (Shrum and Beggs, 1995; Shrum and Shenhav, 1997; Sagasti et al. 2003). Fundamentally, the Internet represents a networking technology that allows users to manage and increase the number and quality of contacts and information searches, simultaneously free of time and space—two network constraints of pre-Internet man (Castells, 2000).

It is evident from this brief chapter introduction that to understand how the Internet may shape the Chilean scientific community necessitates a synthesis of various literatures. Thus, this dissertation considers issues in (1.1) science and technology studies, incorporating analyses of institutional forces and elaborating on the emerging theory of reagency. This dissertation also draws from literatures that address (1.2) historical dependency trajectories in the globalization of culture, and (1.3) social network processes. The intersection of these literatures leads to (1.4) three research questions guiding this study: (1) What social forces have shaped Internet practices within the Chilean scientific community?, (2) How is the Internet associated with the local and global networks of Chilean scientists?, and (3) is the relationship between collaboration and productivity mediated through the Internet?

1.1. Science and Technology Studies

Studies of science and technology (STS) fall into two general categories. Substantively, they examine scientific practices and culture or technological developments and choices

(Cutcliffe and Micham, 2002). Cross-cutting this distinction is a focus on local or global orientations. Variation in scientific practice and technological development between contexts is the foundation of such studies. However, most work on scientific communities focuses on the United States and Western European context (Vessuri, 1987; Gaillard, 1991; Davidson et al., 2003). Of the studies that do examine the impact of the Internet on scientific communities, only a small fraction considers the developing world (Duque et al., 2005; Ynalvez et al., 2005). For the present study, this author is interested in scientific practices (collaboration and productivity) within distinct organizations of research located in the developing world. Therefore, in this sub-section, the study reviews work on (1.1.1) universities and research institutes located in the developing world, (1.1.2) research practices and rewards, (1.1.3) gender in science, and on (1.1.4) the method in which neo-institutionalism theory frames adoption of research and technical practices. The study also reviews (1.1.5) reagency, an emerging STS perspective that lends relevance to a study of cross-cultural resource and technology transfers. The study concludes this section with (1.1.6) a brief review of two policy dimensions relevant to the topics of this investigation.

1.1.1 Universities and Research Institutes in Developing Regions

The literature concerning the evolving world university focuses on the great expansion of higher education throughout the developing world during the 1960s (Phillip, 1976; Beintema and Pardey, 2001; Sagasti et al. 2003). Training home-grown man-power to replace colonial bureaucracies with local capacity was an immediate need. Just as significant a perception was the evolving world university's unique role as a catalyst for economic and social development (Sagasti et al., 2003). These institutions were to work closely with local communities, state and national government and international-development agencies to foster economic and social development (Hulbe and Peters, 1977).[7] Their goals were as follows:

> To meet the national demand for responsible citizenship and effective local leadership, to confront students with practical economic social problems of rural society, to reach villagers and involve them in programs of improvement and to bridge the gap between the college and the larger community.
> (Hulbe and Peters, 1977: 222)

These high expectations where furthered by the characterization of the university as bearer of culture, trainer of skills, frontier of knowledge, and important service agency (Lewis, 1977; Sutz, 2003). Yet, these progressive expectations were challenged by a variety of historical circumstances. First, the "… perceptions of objective academic norms versus proactive social involvement was an obstacle" in reaching these stated goals (Hulbe and Peters, 1977: 222). Often universities in developing nations reflected the institutional structures and attitudes of their ex-colonial hosts, attitudes that did not always meld well within certain postcolonial settings (Drori et al., 2003). This resulted in a variety of internal and external frictions: expatriate faculties versus national faculties; faculties trained abroad versus those trained domestically; the university as a political destabilizing agent (Vessuri, 1987); and the conflicting consequences of developing world universities relying on multi-level sources of public and private endowments from local, state, national, and international environments (Lewis, 1977).

One direct criticism of these institutions was that they often exhibited 'ivory tower' aloofness (Thompson et al., 1977; Moravcsik and Ziman, 1985). The institutions were also readily "… accused of taking more than their share of the national budget," while showing little in terms of improved conditions in the communities they supposedly served (Thompson et al., 1977: 6). One explanation suggests that after colonialism, the rush to legitimize the developing

[7] See Thompson (1977) for an outline of case studies focusing on colleges and universities in the developing world, along with an overview of the general cultural and historical environments within which these institutions developed.

world university was as important as any stated developmental goal (Thompson et al., 1977; Drori et al., 2003). The result was often that developing world institutions were condemned if they did and condemned if they didn't. In the pursuit of pro-active social goals, the institutions risked destabilizing larger structures. Should the institutions avoid social service, focusing on professional legitimacy, they were criticized for being out of touch, or "disarticulated" from local relevance (Moravcsik and Ziman, 1985; Vessuri, 1987; Drori et al. 2003; Sagasti et al. 2003). Regardless of perceptions, universities in these locales have often had to confront severe lack of recourses and public confidence, even when contributing socially relevant research (Sutz, 2003; Sagasti et al., 2003). This has led some scholars to characterize the structure of science in the developing world as "exogenous," as apposed to the organically integrated "endogenous" structures found in most OCED nations. One element of this exogenous profile indicates weak links between local scientific, technological and production capabilities, while these same structures are dependent on strong links with counterparts located in advanced regions (Sagasti et al., 2003).

The literature on state run research institutes suggests a long history dating back to colonial rule and evolving to the present date (Polanyi, 1969; Raina, 1999). In Indian agricultural research, for example, an official central body was created after independence to accredit professionals and fund projects, while coordinating and governing research efforts. The formal goals of research institutes were generally in line with the greater goal of development (similar to academic institutions), especially during the "Green Revolution" push of the 1960s (Shrum and Beggs, 1995; Shrum and Shenhav, 1997; Beintema and Pardey, 2001; Sagasti et al. 2003). Unlike universities that have the added responsibility of creating the next generation of scholars, research institutes are almost completely dedicated to pure research, advancement of field knowledge, and applications to local problems (Raina, 1999; Shrum 2005). In general, state research institutes employ a larger variety of participants with specialized skills (administrators, researchers, technical, and non-technical personnel), indicating a hierarchical system (Shrum, 2000). Raina (1999) suggests this bureaucratization directly manifests a desire to professionalize research from colonialism to the present.

These developmental dimensions of adopted forms, intended goals, local pressures, and bureaucratization of knowledge work have relevance to the case of Chile. Chile's research system retains historic ties to the European Academy dating to the colonial era (Chambers and Gillespie, 2000). In the postcolonial era, globalization introduced new ties to the North. In the present day, Chilean researchers seek professionalization in varied research cultures abroad. How these different research cultures impact the adoption and use of Internet technologies in professional lives is one dimension of this investigation.

1.1.2 Research Practices and Rewards

Much of the literature on university and research institutes located in the developing world suggests a strong reflection of the western or ex-colonial research systems that spawned them (Shrum and Shenhav, 1997; Raina, 1999; Drori et al., 2003). Although few studies have investigated specific research practices in the context of development, the following section focuses on developed world collaboration, publication, and reward patterns.

Collaborative behavior is considered the foundation of human social organization (Hinds and Kiesler, 2002; King and Frost, 2002). In the modern era, scientific collaboration is characterized by specific motivations. For example, output-oriented motivations (Melin, 2000; Lee and Bozeman, 2005) include: (a) access to equipment, (b) skills, (c) materials, (d) visibility, and recognition, (e) efficiency, (f) gaining experience, (g) training researchers, (h) sponsoring a protégé, (i) increasing productivity, (j) multiplying proficiencies, (k) avoiding competition, (l) surmounting intellectual isolation, and (m) confirming research problems. In addition, social motivations for collaboration include enjoying stimulating experiences and even working with old colleagues (Bouas and Arrow, 1995).

Throughout the last century, co-authored publication in the North increased at a dramatic rate (Price, 1963; Gaillard, 1992; Bordons and Gomez, 2000). Among other things, this rise of collaboration was due to the increasing specialization within fields, complexity of research problems, and the high cost of new technology. The recent rise of international collaboration is credited to the growth of basic research, which is more international in nature than applied research. It is also due to the desire of scientists in small nations to find funding opportunities in the exterior (Frame and Carpenter, 1979). This is particularly relevant to understanding the collaborative behavior of scientists in developing regions, where local research capacity and resources are limited.

Sonnenwald (2007) suggested that collaboration involves four stages: foundation, formulation, sustainment, and conclusion. The foundation stage embodies a variety of social dimensions that may promote or inhibit collaborative interactions, such as access to resources or local culture, as well as national and international politics. Institutional setting may also impact collaborative frequency. Comparing research universities with historically black universities (where teaching responsibilities are stressed), the amount of time, resources, and support conducive to collaboration simply does not exist in the latter setting (Sonnenwald, 2006). This may mirror the conditions scientists encounter in the developing world context. Moreover, scientists across field have varying degrees of collaborative behavior (Lee and Bozeman, 2005). Collaboration in the physical sciences often involves a number of individual and group contributors compared to the social sciences. This may result from the need to divide work in quantitative investigations, but not qualitative ones, more generally associated with the social sciences (Laband and Tollison, 2000; Moody, 2004).

Collaboration is also theoretically linked to structural cohesion arguments suggesting the mechanism by which science paradigms develop and are sustained (Kuhn, 1996; Moody, 2004). Senior researchers engage graduate students in collaborative networks of colleagues, which in turn propagate certain research questions, methods, and interpretations. This bears relevance to developing nations that offer few doctoral degree programs across disciplines. Expatriated scholars who seek training abroad often return to home countries with frameworks and methodologies that are relevant in the First World, but perhaps less relevant in the Third World context. This may explain some portion of the “disarticulated” science arguments characterizing less developed regions (Vessuri 1987; Drori et al., 2003; Sagasti et al., 2003).

Most recently, the collaborative benefits of Internet-mediated distributed work suggest a new frontier for science. Rapid innovations in the form of “collaboratories” and “grid networking” facilitated data management and networking at a distance, and across disciplines and sectors (Sproull and Kiesler, 1991; Wellman et al. 1996; Walsh and Byma, 1996; Finholt and Olson, 1997; Hine, 2006). Moreover, email use is significantly associated with reporting fewer coordination problems inherent in collaborative work. This suggests that the adoption of new ICTs may lead to higher productivity (Walsh and Maloney, 2003; Duque et al., 2005).

One perceived benefit of collaboration is a positive relationship with scientific productivity (Lee and Bozeman, 2005). Productivity can be measured in multiple dimensions of type and location. Types include (a) journal and book publication, (b) sections in edited volumes, (c) reports, (d) newspaper articles, (e) extension bulletins, and (f) conference presentations. Location may include publishing in national versus foreign journals, and most recently in cyber space (Nentwich, 2006). Variations in publication patterns on a micro scale emphasize demographic characteristics. For example, previous research has investigated the effect of age on productivity, suggesting an inverse relationship (Bonaccorsi and Dario, 2003). There is indication, however, that this may be a curvilinear relationship. Low productivity characterizes a scholar's early career, while productivity tends to peak mid career, and declines toward the end of a career (Cole and Cole, 1973; Stephan and Levin, 1992). Having a PhD reveals a consistent, positive relationship with publication, as do attending more conferences or holding an office in a scholarly association (Ynalvez et al., 2005). Some authors found gender differences in publication productivity, favoring males (Goel, 2002; Prpic, 2002; Campion and Shrum, 2003), while others found no significant differences in publication frequency between male and female scientists (Gupta et al., 1999).

On the macro level, studies by Garg and Padhi (2000), Ynalvez et al. (2005), and Duque et al. (2005) found contextual and regional differences in publication patterns. It is well documented that different fields publish at different rates (Stephan and Levin, 1992; Laband and Tollison, 2000; Lee and Bozeman, 2005). Compared to social scientists, natural and physical scientists publish prolifically (Laband and Tollison, 2000; Moody, 2004). Developmental context significantly determines the problems that confront those involved in the research process. In turn, collaboration may magnify the obstacles to productivity in resource-poor regions such as in Kenya. However, in well-developed science infrastructures, such as those in India, it leads to increased domestic publication rates (Duque et al., 2005).

Other research has distinguished publication patterns across core and peripheral structures (Crane, 1971; Cole and Cole, 1973; Cozzens, 1990; Moody, 2004). A few prolific scholars produce the majority of publications by field, while the vast majority of scholars publish infrequently. This is of particular interest in understanding publication patterns among developing world researchers, who tend to operate at the periphery of the global scientific community (Shrum and Campion, 2000). The majority of published work across fields appears in journals published in developed countries (Shrum and Shenhav, 1995; Sagasti et al., 2003), many of which are printed in the English language. This practice tends to exclude and isolate non English speaking scholars located in the developing world. My initial research in the Chilean context suggests that this language dimension significantly impacts Chilean publication patterns. Furthermore, early indication is that inequities in publication may significantly magnify institutional context, perhaps due to differing research reward systems.

Generally, participants in universities and research institutes respond to similar career directives. In British and American science structures, the reward system motivating researchers is part contribution and part recognition by fellow scholars, and not necessarily monetary gain (Gaston, 1978; Stephan and Levin, 1992; Zuckerman, 1996). In general, professionalism through accreditation involves periodic evaluation to ensure that research is merit-based and that research strives for bureaucratic autonomy (Raina, 1999). However, the "Mathew Effect" suggests awards, publications, citations, and prestige tend to be concentrated in a self-propelling mechanism among a select few elite scientists and institutions, (Merton, 1968; Zuckerman, 1996). Elite scientists and institutions produce the most publications, are the most cited, and most sought after by the most skilled protégées. As a result, these elite scientists and institutions are the most prolific recipients of grant awards, which in turn leads to more productivity, prestige, and awards. Within the Third World context, elite science dynamics like these should be equally significant.

Another factor influencing scientific practices is institutional legitimacy. Emphasis may differ across academic and research institutes sectors in terms of attitudes toward team work: (a) collaboration versus individual achievement; (b) the primary clients of each institute; and (c) the nature of their work product (i.e., timely service versus quality in the realm of journal publication or prestige in the matter of patents, awards, promotions, and commendations). An added distinction among research sectors is that promotion in the academic setting involves some portion of teaching evaluation. In the research setting, however, research application leading to economic productivity and patents may be more valued than publication. Finally, observations from research visits to Africa and South America indicate that often the organizational boundaries are fluid among academic and research institute scientists. Universities in the developing world commonly have research centers and institutes that employ university professionals. Conversely, national research institute scientists commonly teach at universities for extra income. As types of hybrid professionals, these researchers may be subject to multiple institutional pressures that result in various orientations and outcomes.

1.1.3 Gender in Science

In general, the gender question in science is framed by a "leaky faucet" perspective (Xie and Shaumann, 2003) that suggests the experience of women in science throughout the life course is distinct from men. As a result of socialization, culture, and biology, women tend to have social networks that are more local and familial in nature (Smith-Lovin and McPherson, 1993). These same socio-biological constraints tend to motivate women to drop out at higher rates at every phase of the science career, beginning in secondary education and continuing on through college and post graduate studies. This results in an asymmetrical reflection of gender in science and engineering careers (Cole and Cole, 1973). In the United States, women comprise less than 25 percent of the science sector. This imbalance is magnified in the developing world, owing more to inflexible cultures that marginalize women to mother and homemaker roles (Palackal et al., 2006). This has broad structural impacts that reproduce durable gender inequalities in proceeding generations (Tilly, 2000). Some of the reasons include less female role models in science for young girls to emulate; for those that do choose to pursue a science profession, there are less female mentors in post graduate arenas; and if they succeed in acquiring the PhD, women often find themselves working in a male dominated environment (Long, 1990; Fox, 1999).

Implications for science in developing regions are empirically addressed with regard to gender differences in professional networks, collaborative behavior, publication rates, and technology adoption (Campion and Shrum, 2003; Duque et al., 2005; Ynalvez et al., 2005; Palackal et al., 2006). Studies in India suggest that "patrifocal" constraints embedded in the culture geographically determine with whom women can associate (Gupta and Sharma, 2002; Palackal et al., 2006). As a result, Indian women scientists encounter limitations in the opportunity to network outside local regions. This seriously impairs their ability to compete with male counterparts since international training and collaboration often offer resources and prestige that are not available domestically. Still, studies in Africa and India found minimal gender differences among scientists in regard to publication. However, there are differences that favor men in terms of acquiring a PhD, traveling abroad for training and visits, and publishing in foreign journals (Campion and Shrum, 2003; Ynalvez et al., 2005). Over time, these differences suggest a continued imbalance in outcomes.

New ICTs are predicted to change this structural pattern by allowing women in developing regions to circumvent "patrifocal" limits without upsetting cultural norms (Palackal et al., 2006). Studies on Internet adoption in the North suggest a reduced gender gap of adoption and varied use over the last decade (Pew Internet and American Life Study, 2000; NTIA, 2004). These findings appear to support the prediction, but past research on technology adoption in impoverished regions suggests that males are more likely to adopt and employ innovations (Rogers, 1995). Furthermore, some scholars contend that new ICTs will continue to evolve along similar male-dominated patterns, as reflected by past development projects (Escobar, 1995; Ekdahl and Trojer, 2002). This does not bode well for gender equality in developing world science through Internet adoption and use.

1.1.4 Neo-institutional Perspective

As suggested earlier, developing-world institutions of research and learning are often-times patterned after Northern models, rituals, and practices (Shrum and Shenhav, 1997; Drori et al., 2003). Many scholars assume a critical view of the establishment, development, and present state of these types of organizations (Polanyi, 1969; Pyenson, 1985; Vessuri, 1987). Some note a lack of resources and commitment from within the larger society (Vessuri, 1987; Sagasti et al. 2003). Others point cynically to the entrenched global structure that has systematically marginalized Third World science (Sagasti, 1973; Gaillard, 1991). The tendency of the international scientific community to provide rewards for addressing a limited range of basic research issues tends to further disenfranchise developing world scientific communities (Cole and Cole, 1973). Moreover, their contributions are frequently discounted (Gaillard, 1991; Davidson, et al., 2003). As a result, Third World research institutions often find themselves isolated from global science. Furthermore owing to the lack of resources and need for global recognition, these marginalized institutions often pursue research without local relevance, while they are at time seen as threats to state hegemony (Vessuri, 1987; Sagasti, et al., 2003). Many of these conditions reflect the recent history of the Chilean research sector. And like in other developing regions, these conditions have caused intellectual flight among the best and brightest of a scientific community and engender low productivity among those who choose to remain.

In citing the causes and consequences of these arrangements, both STS and neo-institutional scholars note that organizations tend to re-enact and reproduce the legitimizing structures of their Northern counterparts, even at the expense of efficiency and goal achievement, (Meyer et al., 1997; Drori, et al., 2003). Traditionally, neo-institutional scholars suggest that cultural and societal environments determine an organization's goals and structures, as well as the behaviors of their participants (Scott, 1998). Legitimization is more often attained through adherence to set range of normative cultural scripts, structures, and behaviors. Over time, the neo-institutional perspective contends, institutions become captive to their environments because legitimacy reduces uncertainty in terms of acquiring resources, adhering to regulation, and winning over constituents or customers (DiMaggio and Powell, 1991).

Adherence to the common practices of an organizational field is also considered a tenet of this theory, commonly termed "organizational" isomorphism. This concept has parallels with dependency perspectives outlined later (Shrum and Shenhav, 1995). An isomorphic standardization of structure and leadership tend to mirror accepted societal forms and behaviors. "Coercive" isomorphism" refers to when Institutions respond to societal expectations, state regulations, and even normative restraints enforced by funding agencies and prolific institutes or individuals. This is of particular relevance to scientific communities in developing regions, since local projects are often initiated by resources and agents from abroad (Shrum, 2005). These resources and agents tend to project their own practices and methodologies for assessing outcomes (Shrum and Shenhav, 1995). "Mimetic" isomorphism occurs where there is uncertainty. In such an environment, organizations tend to copy forms from successful entities in their field. "Normative" isomorphism occurs when professional roles and behaviors are standardized. This standardization obligates new entities and agents to conform in order to receive accreditation (Torres, 1988). This is clearly the case for research professionals across national and sector contexts. Normative isopmorphism compels organizational participants to adhere to (a) a distinct occupational position, due to the influence of multiple organizational pressures; (b) a bureaucratic position, influenced by the institutions where the researcher works; and (c) a professional position, designated by associative fields in which the participant was trained (Drori et al., 2003). Participants in the research sector often follow two sets of isomorphic predictors: organizational and field level.[8]

To summarize, the neo-institutional perspective suggests that organizational types exist and reproduce as a result of adherence to a set of prescribed societal scripts, forms and behaviors. Mimicking, or consistently following that form from which an organization derives its identity, determines legitimacy. Generally, developing world research institutes are not as entrenched in the pomp and circumstance of traditional university forms, or the "ivory tower" critique. The goals, structures, and participants tend to be more reflexive to the immediate social environment. As indicated in Raina (1999), bureaucratic autonomy vis-à-vis professionalization, coupled with an evaluation of good-works, indicates a desire to streamline forms and improve practices. Thus, these types of organizations may be less restricted by tradition and more open to new ideas and technical practices than are university departments. This suggests a possible distinction between these two types of organizations in terms of Internet adoption and practice.

[8] Scientific research is conducted across a variety of disciplines working in various sectors (corporate, non-governmental, government and academic institutes). This present study considers various natural and social science fields working in two types of organizations—university departments and government research institutes.

Regardless of type, organizational practices can occasionally deviate from the normative structure. The agency perspective offers insight into how this may occur. The following section analyzes the confrontation between competing agency orientations in the developing world, or the phenomena of reagency.

1.1.5 Reagency

Reagency refers to the bi-frication of relational goals and actions when cross-cultural agency continuums interact (Shrum, 2005). This process theory is drawn from a large body of work on "human agency" (Mead, 1932; Bourdieu, 1977; Joas, 1996; Emirbayer and Mische, 1998). For example, Emirbayer and Mische (1998) contended that agency is best framed within a temporal continuum, listed as: (a) iterational or selective reactivations of past scripts, (b) projective creative reconfigurations of future trajectories, and (c) practical-evaluative or normative judgments of present alternative responses. Since "many non-Western cultures have alternative constructions of the relationship between past, present and future, which constrain and enable particular forms of social creativity and reproduction", interactions of First and Third World orientations oft-times may result in inefficient outcomes (Emirbayer and Mische, 1998: 985). The emerging reagency perspective attempts to illustrate this cross-cultural agentive interplay. With regard to the underwhelming results of development, some studies suggests that donor resources are often redirected or "reagentized" by indigenous interests to meet local imperatives even at the expense of preconceived developmental goals (Shrum, 2005; Duque et al., 2005).

An observed example comes from donor agency drivers, or chauffeurs, in developing areas. These chauffeurs often face pressure from family and acquaintances to divert the use of official vehicles to satisfy immediate needs for free taxi service; this pressure is termed “indigenous principle-agent control.” The drivers comply with the local demands for free taxi service, even in the face of stiff reprisals from donor employers (Edwards and Rosberg, 1976). This situation reflects a typical indigenous “principle-agent problem” (Davis, 1991). The result represents fulfillment of both the rational-universalistic construct in the use of these vehicles (Weber, 1938; Lispset and Lenz, 2000), and the particularistic, socially construct in local culture obligations in which these drivers are socialized.

While broad in its conception, empirical evidence for the reagency of the Internet may already be manifest. One can imagine a host of unofficial uses for these kinds of relational and information technologies. Many have already been employed in the First World as evidenced by restrictions on corporate America in personal Internet use during working hours (Young and Case, 2004). In this case, the Internet became the catalyst for a clash between First World corporations and ever expanding leisure culture. Some of the reagentized offenses included: conducting personal business over email, “chatting,” downloading music and pornography, shopping on line, playing online games, trading on the stock market, and most troubling, conducting company fraud. These cyber behaviors are estimated to cost corporate America close to $54 billion in annual losses.

Similar alternative responses in the developing context would include “the Nigerian Scam” emails most computer users commonly receive; credit card fraud originating from developing world Internet cafés; and Al Qaeda employing transnational domains like Yahoo and Hotmail to coordinate global terror from remote Internet cafés throughout Western Europe and the United States. More mundanely, professionals in developing regions may employ the Internet during working hours to conduct entertainment and personal affairs much like their First World counterparts. Downloading exotic items may be problematic, though, since local connection speeds are slow and personal computers outdated. Given the narrow diffusion of this technology outside academia, government, and perhaps business, the notion that developing world researchers will be chatting with local non-professionals is unlikely. However, researchers could be chatting with expatriated friends, family, or foreign acquaintances abroad.

Conducting online banking, market trades, or even purchasing durable items and services becomes a possibility, albeit remote, with companies located in developing nations. However, it is quite possible to conduct these transactions with transnational online e-companies, provided the users have credit.[9] All of these possibilities suggest an international reagentive-orientation for Internet use in less developed regions. Many Chilean scholars recently have admitted that they commonly use the Internet to circumvent restrictions placed on the most recent journal articles in their field. This is accomplished by emailing professional colleagues abroad or by directly contacting authors to request digitally forwarded articles. These scholars argue that this "victimless crime" is necessary, given the imperative to publish in ISI journals that necessitate reviewing the latest literatures. This is not always possible due to inadequate local library resources, while the purchase of single copies of recent works remains prohibitively expensive.

While most of the examples given seem harmless, it is not difficult to imagine that over time, reagency may lead to an accelerated depletion of resources and a decline in donor trust. This can often lead to a donor's hesitation to complete, or reinvest in future, projects. A vicious cycle ensues where-by new resources are diverted, funding pulled, and projects are left incomplete. The negative results might explain the low expectations and impoverished conditions of many developing world regions. In this sense, the reagency perspective serves as an alternative to the well-worn dichotomous debate between modernization and dependency

[9] In the African context, credit cards are rarely accepted in non-tourist locations. Many banks do not even offer them. Still some developing-world professionals do manage to obtain them. But this is the exception and not the rule. In the developed context, credit card access and use among professionals is the rule.

theorists. It also suggests why the global knowledge divide exists. Moreover, global science policy that continues to promote progressive ideologies and the isomorphic dynamics of Western-style development, while ignoring reagentive forces, could prove to be the mechanism that cements this enduring inequality.

1.1.6 Science Policy

Literature treating policy issues remains closely interwoven with the perspectives reviewed. Policy studies analyze controversial negotiations between science, industry, and the state, and in particularly 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; Cardosa, 1972; Sagasti, 1973; Frobel et al., 1980; Vessuri, 1987; Escobar, 1995; Sagasti et al., 2003). Two recent examples of global policy discourses directly relating to this present investigation 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 example, due to historical and contextual processes that have resulted in a sharp rise in science productivity and co-authorship in the First World, collaboration has emerged as a "scientific good." It is even considered a panacea for knowledge production in the less-developed areas (Duque et al., 2005). As a result, collaboration has often been blindly adopted and promoted by donor funding programs, conferences, and policy frameworks regardless of the unintended negative consequences it may have in many impoverished regions (Duque et al., 2005). Recently, the Millennium Project, sponsored by the World Bank, has promoted cross-national scientific collaboration among scientists located in developing regions. Yet the accepted study of collaboration through bibiometrics data, on which the project bases optimism, has been widely criticized. Although bibiometrics 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). 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).

Another example is the multi-lateral promotion of new information and communication technologies (ICTs), like the Internet, in developing regions. This process was best illustrated at the last World Summit on the Information Society, phases one (Geneva, 2003) and two (Tunis, 2005). National and global policy makers, scientists, as well as representatives from the private sector and civil society, converged to discuss bridging the global "digital divide".[10] Global ICT policy emphasizing the rapid diffusion of the Internet throughout the developing world came as an immediate result. However, the policy places pressure on the governments of less developed regions to open telecommunication markets to global actors, thus jeopardizing local control of strategic utilities, and thus self determination. Some suggest that the unintended consequences of these pro-active policies may actually reinforce existing asymmetry between core and peripheral nations in terms of scientific capacity and economic production (Parayil, 2005) because the policy does not adequately address the underlying causes of dependency. The causes of dependency often emanate from a colonial legacy of entrenched interests, coupled with unstable primary resource markets, and unfair trade terms (Kerbo, 1978; Wallerstein, 1979; Arocena and Senker, 2003). Substituting inefficient local control of information and communication for global influence may be a short term solution, but not a long term one.

Far from resulting in self-sustainability, these two recent policy initiatives, (1) the institutional adoption of developed world science and (2) the global diffusion of new ICTs, may actually strengthen the structural hegemony of western norms and practices and continue dependency on the North. This is because the continuance of these norms and practices may come at the expense of local needs and cultural ways of knowing (Frobel et al., 1980; d'Orville, 2000). Recent policy discourses treating the global knowledge and digital divides have raised issues. As policy, the discourses tend to intersect classical arguments and counter-arguments by scholars studying global development over the past half-century. The following section treats these development perspectives more directly.

[10] The digital divide refers to the increasing ICT gap between the First and Third World that threatens to isolate further the less-developed world. Some suggest the unintended consequences may lead to further global inequity and perhaps instability (Hedley 1999; Parayil, 2005).

1.2 Development Studies

The Internet is quickly diffusing throughout the developing world. There is hope that this new technology will re-invigorate global development efforts and fulfill aspirations for self-sustained growth (Melkote, 1991; Woods, 1993; Sagasti et al., 2003). Although the Internet represents a relatively recent social phenomenon, scholars point to the digitally mediated social forces that already unfold within the First World [11] (Hurd and Weller, 1997; DiMaggio, et al., 2001; Woods, 1993; Quan-Haase and Wellman, 2002; Castells, 2000; Arocena and Senker, 2003). This phenomenon is especially relevant to the study of developing world science, since Internet technologies were first innovated by First World science; these original use patterns are expected to replicate within less-developed regions (Castells, 2000; DiMaggio et al., 2001; Shrum, 2005). However, the Third World represents an array of developmental histories and demographic attributes, influencing the way in which the Internet diffuses (Shrum, 2005). Latin America, in particular, embodies unique historical dependencies, distinct from other regions (Arocena and Senker, 2003). To understand this dimension more clearly, this study reviews three development theories: (1.2.1) modernization, (1.2.2) dependency, and (1.2.3) globalization, and the manner in which these perspectives might frame the way the Internet shapes Third World science—the <u>elixir</u>, <u>affliction</u> and <u>teething</u> outcomes (Davidson et al., 2003; Sooryamoorthy et al., 2005).

1.2.1 Modernization Theory

The modernization theory views development as an evolutionary, ahistorical, and uni-linear process, through which all societies pass. This progressive perspective builds upon 18th

[11] The Internet is credited with, among other things, decentralizing organizational and informational structures; expanding global and local consumer markets; providing new digital mechanisms for the creation and dissemination of cultural knowledge and entertainment; and having impacts on the quantity and quality of social and professional networks, which increase social capital and political participation (DiMaggio, 2001; Castells, 2000).

century structuralist arguments that suggest a natural movement from traditional to modern societies. Modernization scholars contend that this transition simultaneously involves economic, political, social, cultural, and psychological developments. By adopting First World modes of science and technology, production, democracy, mass media, and achievement orientations, the Third World was expected to accomplish growth and self-sustainability (Lerner, 1958; Rostow, 1960; McClelland, 1961; Lewis, 1968; Inkles, 1969; Huntington, 1971). One critique of modernization theory is that it

> … denies the possibility of conflicting rationality between the national and international spheres by arguing that integration of all national economies whether developed or developing into the international capitalist system is always beneficial for all countries. (Bienefeld, 1982: 2)

Within this perspective, technology is considered rationally driven, deterministic, and the natural product and engine of modern social cohesion. Durkhiem (cited in Roberts and Hite, 2000: 49) suggests "… the increased number and speed of the means communication and transmissions due to progress abolishes or lessens the vacuums separating social segments, thus increasing the density of society." Therefore, the diffusion of the Internet is predicted to be a neutral process that unfolds beneath an umbrella of progress and social integration. Internet adoption, within the developing world, is expected to continue as a rational-functional development associated with modernity. Concurrently, developing world science anticipates adopting and benefiting from these innovations in much the same way as their Northern counterparts. As a result, this orientation supports an elixir argument, whereby Third World science employs the networking and information gathering capacity of new ICTs to enjoy local relevance and global visibility.

1.2.2 Dependency Theories

In contrast to modernization theories, dependency and world systems theories[12] observe the world as evolving in a historical, dialectic process that results in a continuous and exploitative relationship between core and periphery nations (Frank, 1969; Wallerstien, 1979; Escobar, 1995). Western-style development promotes free market trade, allowing nations to structure their economies to exploit a particular, comparative advantage. Since the developing world possesses a bounty of primary resources and cheap labor (low, added-value products are often inputs for First World products), logic suggests that the developing world should fuel growth by relying on these assets. In contrast, the First World enjoys a comparative advantage in manufacturing, science and technology, entertainment media and services (high, added-value products that tend to frame and define world-wide modernity).

Developing world populations tend to adopt consumption patterns of their First World counterparts creating a mechanism for capital flight from the Third World to the First World. Moreover, trade terms frequently favor developed world products at the expense of primary inputs, because primary inputs often are affected by volatile market fluctuations. Although development loans may balance trade deficits, the loans tend to be oriented toward First World technicians, products, and services. Donated infrastructure assets do not necessarily build local capacity or support the proliferation of local input markets. This cycle of capital flight, decreasing returns to primary exports, and exogenous development loans continues dependency relationships.

Further complicating the development process, economic reorientation may lead to civil unrest. Competition over scarce resources ensues between well represented industrial agents

[12] Dependency theory commonly refers to a host of inter-related perspectives that include World Systems, dependent development, and urban bias. Although they have some distinctions, they share the general conclusion that there exists an entrenched global structure that benefits the developed world to the detriment of the less-developed world.

against marginalized, rural subsistence cultures (Urban Bias)[13], while local elites compete for power.[14] The process often leaves developing world nations vulnerable to civil wars, corrupt administrations, loan defaults, and opportunistic global capital, all of which threaten self-sustained growth. Meanwhile, the developed world enjoys a competitive advantage, cheap primary inputs, and stable growth. This is why observers consider development a zero-sum gain, when outcomes show that the First World has developed at the expense of the Third World (Cardosa, 1972).

To address the empirical shortcomings of this perspective,[15] dependent development theory suggests that growth is possible within a tutorial relationship (Gereffi, 1994). In a more moderate expression of dependency, core nations invest capital and transfer technology into particular peripheral economies. Initially, core and periphery elites benefit at the expense of Third World populations (Evan, 1979; Montener, 2000). Eventually, a stable environment is created whereby development is self-sustained through economic restructuring and reinvestment. This results in mutual growth and the creation of semi-peripheral world nations.

Dependency theorists characterize technology as anything but neutral. Marcuse (cited in Ritzer, 1983: 252) suggested, "[Technology] is effective because it is made to seem neutral,

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[13] Urban bias theory (Bradshaw, 1987) argues that traditional development promoted investment and tax incentives that disproportionately favored urban areas in less developed nations. Moreover, local industry and urban labor pressure the state to re-direct investments to cities at the expense of rural areas. This often pits traditional rural and emerging urban interests in a sometimes violent struggle for power.

[14] The Cold War exacerbated the structural obstacles to development in many Third World regions. First World foreign policy, especially originating in the United States, often supported repressive dictatorships that were friendly to free market orientations and resisted communism. The resulting human rights violations and rampant government corruption, which accompanied these regimes, often sacrificed developmental gains. This creating risky investment environment that may have compromised future prospects (Harrison and Huntington, 2000).

[15] South Korea, Taiwan, and Singapore experienced high levels of growth through foreign investment and economic restructuring in the post-WWII era. The result was a dramatic transformation from subsistence to modern manufacturing and service economies in a relatively short period. Cultural arguments suggest that they succeeded because these traditional societies possessed high levels of social integration and work ethic (Harrison and Huntington, 2000). Geo-political arguments suggest that the success of these economies was vital to offset Red China's hegemonic aspirations. The West, through free technology transfers, low-interest loans and favorable terms of trade, functionally subsidized these economies for political ends (Gereffi, 1994). The Chilean economic miracle over the last 30 years is often criticized for characterizing similar geo-political imperatives.

when it is in fact enslaving. Technology, no matter how pure, sustains and streamlines the continuum of domination." Cardosa (1972: 175) adds that this "… is the reason why *technology* is so important. Its *material* aspects are less impressive than its significance as a form of maintenance of control and as a necessary step in the process of capital accumulation." Unlike progressive assumptions, the diffusion of the Internet is considered a tool of a new kind of colonial discourse (Escobar, 1995). It stream-lines operations and extends the reach of global capital, which further benefits First World populations and Third World elites (Arocena and Senker, 2003).

Furthermore, some suggest the Internet is only relevant to northern institutions of knowledge creation and has little lasting application in low, technological environments. If anything, the Internet threatens to continue siphoning off the most talented indigenous scientists into international collaborations that address First World concerns at the expense of developing world ones. As a result, dependency foreshadows an <u>affliction</u> argument with concern to the Internet's potential influence on Third World science. At best, dependent development allows for a tutorial or <u>teething</u> relationship. Initially, it may prove problematic as Third World science struggles to incorporate these new technologies within technologically handicapped regions. Given the right circumstances, however, such as science policy reemphasis, deregulated telecommunication markets, and upgraded technological infrastructure, the Internet may eventually pave the way to a symmetrical global scientific community, but only in certain areas.

1.2.3 Globalization Theory

Less pessimistically, globalization perspectives pragmatically consider the dynamics of an increasingly interdependent world community. Scholars observe a fluid integration of transnational plains, financescapes, ideoscapes, ethnoscapes, and culturalscapes, making the world a singular, networked space (Appaduria, 1996). Globalization is most readily associated with growing worldwide trends toward democracy, capital markets, and mass consumer cultures. Culturally, globalization theorists observe the forces of homogenization and Westernization in relativistic terms. The theorists consider "hybridization" (Escobar, 1995) or "glocalization" (Robertson, 2001) to be more empirically accurate metaphors for the melding of global cultures. Periphery regions adapt global ways of producing, thinking, and being, in order to fit indigenous realities. In turn, immigration permits western societies to readily absorb and maintain the symbols and modalities of traditional cultures. These concepts mirror the reagentive cross-cultural process outlined in the previous section, albeit in a more positive light.

Transnational media, air travel, new ICTs, and multi-national corporations drive globalization by integrating global cities into one networked whole (McMichaels, 1996; Sklair, 1995; Castells, 2000). However, scholars studying global trends are critical of capital market-driven development, suggesting that such development hinges on mass production and consumption. The Internet is poised to increase the awareness, rapidity, and intensity of global markets. This may escalate pressures on already depleting world resources and fragile ecologies, thus threatening sustainable development throughout the Third World (Sutcliffe, 1995).

Concerning the globalization influences of the Internet, Frobel et al. (1980) questioned whether new ICTs are significant to the Third World, since they depend on foreign specialists and managers for setup and maintenance. "Moore's law" [16] has application here. Internet innovation is so rapid with the constant upgrading of soft and hard infrastructures that the

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[16] "Moore's Law" is named for Gordon Moore, one of the founders of the chipmaker Intel. He predicted that the computer power available on a chip would approximately double every 18 months, thus continuously making obsolete previous generations of technologies (Brown and Duiguid, 2000).

developing world will never succeed in developing indigenous ICT industries.[17] Thus, the Third World may be forced into a long-term digital dependence. Mirroring the suggestion of dependency perspectives outlined above, developing world science could continue to be the collaborative puppet of the First World—the affliction argument. As implied by a more pragmatic translation of "glocalization" (global and local), the Third World could first adopt and then adapt the Internet over time to address local problems: the teething argument.

To review, globalization scholars suggest that cultural and economic asymmetries are drawn to a process of absorption and dissolution, owing to advances in information and communication technology. This signals the dawn of a new kind of "supra-national" cultural understanding that will transform this present world into a timeless and spaceless kaleidoscope of cultural practices mediated by new ICTs (Robertson, 2000; Castells, 2000; Uimonen, 2001). NGOs such as scientific and development associations are considered key conduits to the construction of a globally networked civil society. These associations embrace common and overlapping understandings, unbounded by national borders or regional interests, and provide a unified voice to influence national and international policy (Crane, 1971; Blume, 1997; Drori et al., 2003). In this emergent "networked society" (Castells, 2000), the quantity and quality of local and global ties will translate into varied outcomes for the scientific communities located in developing areas. The next section describes the social network and diffusion of innovations perspectives in more detail, as well reviews the implications for STS and development studies.

1.3 Social Networks, Diffusions of Innovations, Science Networks, and New ICTs

Two interrelated literatures that may be useful in understanding new ICT adoption and use patterns are social network and diffusion of innovations perspectives. Closely associated

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[17]Two exceptions are India and Brazil, which have developed their own ICT infrastructures in the last decade. Although, they do not yet compete with the technological powerhouses of the West.

with social networks, social capital is the "value" individuals receive from their social relationships (Bourdieu, 1985; Coleman, 1988; Lin et al., 2001). Social networks analysis is a framework in which an organization or an individual's social capital potential may be seen to vary, given their position within different network configurations (Lin, et al., 2001). Diffusion of innovations perspectives describe social profiles and dynamics to determine how, and among whom, resources flow within networks (Rogers, 1995). In this sub-section, (1.3.1) social networks and (1.3.2) diffusion of innovations perspectives will be treated separately in order to distinguish unique contributions to a study in how new ICTs will shape developing world scientific communities. This section will conclude with (1.3.3) a review of science networks and how new ICTs shape them.

1.3.1 Social Networks

Social network and social capital concepts offer a powerful, analytical perspective. These concepts are employed in small world studies as well as studies of organizations, development, and science (Milgrim, 1969). [18] The concepts seek to understand the ways resources are distributed within networks, resulting in stratified outcomes. The social network approach makes explicit the structural constraints and potentials inherent in interpersonal networks, involving such characteristics as tie strength, density, size, diversity, and range (Granovetter, 1973; Rogers and Kincaid, 1981; Burt, 1983; Burt, 1992; Borgatti and James, 1998; Hurlbert et al. 2001; Lin et al., 2001). Tie strength—the bonds of trust among individuals that result from frequent and/or intense contact—can translate into a variety of resources and

[18] In the mid 1960s, Stanley Milgrim (1969) conducted an experiment to measure how long and through how many intermediaries it would take to connect two complete strangers across the continental United States. Averaging out the various pairs and the links that connected them, Milgrim concluded that it took approximately six links to connect the average pair of strangers in a modern society. This was then popularized by the phrase "6 degrees of separation", upon which a stage play and movie was based, and then the popular Hollywood board game "Six Degrees of Kevin Bacon".

support for scientists (Shrum and Mullins, 1988). Weak ties, though, offer avenues for new information and technologies, and employment opportunities.

The concept of structural holes illustrates the advantages of weak ties. Burt (1992) argued that in an imperfect market, (a) participants do not have equal knowledge, (b) uncertainty is prevalent, and (c) decision-making time is scarce. In these markets, some individuals exist within structural positions that afford them exclusive access to important and ready information. These types of individuals serve as weak tie bridges between individuals, groups, or organizations that may not otherwise be connected. The benefits that accrue to bridges include access to immediate, and often inside, information about new products, mergers, regulations and well connected others.

Although bridges are profitable in business, research on knowledge networks suggests that it is strong ties rather than weak ones that are focal avenues for the transfer of scientific information (Murray and Poolman, 1982). This may be especially relevant to “complex knowledge” transfers, where weak ties hinder, rather than facilitate access (Hansen, 1999). Research on organizational outcomes contends that some combination of weak ties that provide access to innovation and strong ties that provide access to complex knowledge is beneficial (Uzzi, 1996).

The density of one’s network or the degree of overlap among contacts suggests strong support. However, this density may inhibit innovative information and behavior, since information is redundant in dense networks and deviating from network norms may result in sanctions. A related concept is *multiplexity*, the degree to which multiple types of relationships or content messages flow through a dyadic link. Multiplexity signifies a high degree of tie strength. Furthermore like density, multiplexity displays a resource redundancy and social control that may retard adoption of innovations.

Heterogeneity is defined as the variety of contacts with respect to sex, age, race, occupation, and talents. Diverse networks often provide new information and resources (Blau, 1977; Popielarz, 1999; Burt, 1983; Shrum and Beggs, 1987; Lin et al. 2003) that may lead to increased productivity. However, diverse networks also may result in coordination difficulties (Rothschild-Whitt, 1979; Sirianni, 1994; Huang, 2006) that could inhibit productivity. Heterogeneity has been found positively related to network returns, except when it conflicts with compositional quality (Shrum and Beggs, 1995).

Compositional quality is defined as the number of contacts with high levels of needed characteristics, such as total wealth, power, expertise, or generosity of contacts. The more a researcher is connected to useful others, the more social capital gained, regardless of the variety of contacts. A related concept, *range* (Burt 1983), refers to the level of diversity and reach, minus a redundancy factor, into other institutional networks—academic, business, and government. In the developing context, one's range could translate into collaborative links with institutions and scientists in the exterior.

The Internet has been found to influence the growth of professional networks (Hesse, et al., 1993; Walsh and Byma 1996). The cyber benefits of extending collaborative links across field and national boarders are well documented (Sproull and Kiesler, 1991; Wellman et al. 1996; Walsh and Byma, 1996). However, these benefits accrue to those that adopt and maintain consistent access to new networking technologies. Diffusion patterns for these technologies vary. Access and use is often determined by historical, cultural, demographic, and political-economic factors. The following section treats the diffusion topic in more detail.

1.3.2 Diffusion of Innovations

The diffusion of innovations perspective is closely intertwined with the social-networks approach. Studies have investigated the transmission of new agricultural techniques through networks of developing-world farmers, as well as family-planning dissemination within stratified rural communities (Rogers and Kincaid, 1981; Rogers, 1995). These investigations suggest that an adoption of new techniques is associated with youth, wealth, education, cosmopolitanism, and being male. In regard to new relational technologies such as the Internet, this perspective also supports the importance of network externalities (Katz and Shapiro, 1985). Network externalities represent the increased value and reduced cost to users, who in turn further increase the number of users who join the network. This explains the wide adoption of networking technologies like cellular telephony. Yet the overlap of distinct class and sector networks is also vital to the diffusion of technology (Rogers and Kincaid, 1983; Robertson et al., 1996). This allows new information to travel vertically through class hierarchies and across sectors. In developing nations, though, a critical mass of adopters is often lacking where class distinctions are marked by gross inequity (de Janvry and Garramon, 1977) and sectors are either uncoordinated or characterized by mutual suspicion (Sutz, 2003; Patterson and Wilson, 2000; Sagasti et al., 2003).

Supporting this notion, are social capital studies conducted in the Third World. This distrust is theorized to be a result of modernization—when traditional, rural, strong ties are replaced by modern, urban, weak ties (Narayan and Pritchett, 1999; Grootaert and Van Bastelar, 2001; Narayan and Cassidy, 2001). As traditional ties break down, they are replaced by interest-laden relationships that compete over limited resources. This tends to pit local elites against one another for donor patronage. Moreover, a cultural argument contends that traditional societies are embedded with particularistic ways of being; consequently, traditionalists naturally distrust strangers and strange techniques, opting instead for the familiar, even if that choice leads to continued impoverishment (Fukuyama, 2003). The former critique suggests a modern disintegration of local networks in developing regions, while the latter argument suggests an embedded cultural resistance to new technologies. Both these deflate optimistic predictions for the successful diffusion of the Internet in many parts of the developing world.

Also relevant are studies on the diffusion of northern technologies into the Third World. Citing cross-cultural transfers of technological artifacts, Lemonnier (1993: p. 12) suggests, "In order to be assimilated, a technology feature has to fit physically with already existing practices." The Internet was innovated and developed within a specific technological environment characterized by the inter-dependence of free capital markets and a pluralistic political system. Advanced information societies in the North have the appropriate cognitive, technical, and organizational networks, or technological ensembles (Bijker 2000), that support and sustain Internet technologies. In contrast, the technical heterogeneity[19] found in many developing regions, limits the ability to adopt and successfully employ modern innovations on a society-wide basis. At best, cooperative relationships between the North and developing regions can result in resource asymmetries that create technical dependencies. At worst, valuable development resources can be wasted and societies overwhelmed by modern diffusions.

These kinds of contextual obstacles to diffusion are documented in previous technology transfers that have failed in some developing regions. For example, Akrich (1993) documents

[19] In much of the Third World pre-industrial and post-industrial environments exist side by side. Internet technologies require post-industrial technological ensembles (Bijker, 2000) that include reliable electrical sources, climate controls, technical support and competitive markets for energy, financing, connectivity, and computers and networking. Also, they require an educated population of users with disposable incomes that find Internet content and applications relevant and have the cognitive and physical skills to navigate them successfully. The homogeneous degree to which these elements exist may determine how successfully the Internet will be diffused within the wider populations of developing world nations.

the social circumstances that prevented the successful adoption of a French-made wood-burning energy generator in Costa Rica. Produced for temperate zones that have technical networks with ready capital, parts and support, the generator failed in an isolated tropical region. Another example is the contemporary transfer of industrial techniques into the pre-industrial economy of Sri Lanka. In this case, the subsistence island culture was unable to overcome the social displacement that occurred to catastrophic results (Pfaffenberger, 1993). A more relevant example to this study is the failed case of the land line telephone and television diffusion throughout Sub-Saharan Africa over the last half century (Castells, 2000). There is some optimism though. Reports indicate that adoption of cellular phones seems to be on the rise in the metropolitan regions of most developing nations. However, Internet connectivity, especially in Africa, is a very tenuous prospect (Del Roy, 1997; Jimba and Atinmo, 2000; Shrum, 2005). It is still relatively expensive, unreliable, and in some cases dependent on foreign aid.

While scientists in developing worlds may be immune to the cultural and environmental obstacles to diffusion, the obstacles are embedded in social systems that are not conducive to change. Thus, the extant social system could determine the types of local support, resources, and networks that are available outside an organization. In contrast, First World scientists benefit from a society-wide preference for newness. Also helpful is the general institutional trust characterizing Northern societies. This trust is supported by universal normative and legal infrastructures, as well as highly integrated technological ensembles that safeguard against environmental and social unpredictability. However, the African context of one study looking at Internet adoption differed from the south Asia context, suggesting that developmental scale matters (Duque et al., 2005). Concurrently, this author's investigation in Chile—a regional socio-economic leader—indicates that the relationships between technology, social networks, and scientific practices may be positively shaped by development status. More specifically, Internet access there, unlike in sub- Saharan Africa, is widespread and supported by the public and private sector. To temper this, qualitative interviews suggested that the internal digital divide still favors higher socio-economic status and youth.

1.3.3 Science Networks and New ICTs

The importance of professional networks in science can never be understated in terms of resources and influences these networks can employ, as well as their lasting impacts on society at large (Crane, 1971). The rise of modern science in the last 500 years is often credited for developing the phenomenon of transnational communication networks (Chambers and Gillespie, 2000). This also resulted in the organic integration of global science within government and industry patronage ensembles (Sagasti et al., 2003). The actor-network perspective (Callon, 1987; Latour, 1987) suggests that scientists rely on two kinds of networks—*research* networks and *resource* networks (Cozzens, 1990). The research network is composed of other researchers within a field of interest in which an individual shares a formal or informal tie. Links within the research network are valuable for sharing new information and gaining professional support. At first the links are informal, consisting of personal and professional interchanges among colleagues—"the invisible college" (Price, 1967; Crane, 1971). Over time these relationships may grow into formal science associations, and then transnational organizations of science, mediated by journals publications and annual conferences (Crane, 1971). The resource network involves linkages between science and its patrons, which are government and private science funding agencies. Within the resource network, science networks continually enroll patrons by translating research activity into social values applicable to public health, profit, and national defense.

Research and resource networks may be organically reflexive. On one hand, research networks can grow in number and quality by means of systematic patronage, a co-opt process that facilitates specific economic or political ends. On the other hand, patrons can be enrolled into research networks with the size and range to lobby vigorously for resources or with a quality of output that draws intrinsic interest from funding agencies.

Over time, research and resource networks can become so embedded in a society that institutional forces determine the social value of science for the sake of science itself (Cozzens, 1990). In this institutional atmosphere, science may receive patronage to pursue pure research with an absence of utilitarian social goals. Pure research provides the seedbed for recent innovations in the golden age of science, supplying the foundation for technical advancement since the mid-to-late 20^{th} century (Cozzens, 1990; Sagasti et al., 2003). Furthermore, it is this process that helped create the endogenous structure of First World knowledge that combines science, technology and production capacities into an organic and coordinated system (Sagasti et al., 2003).

Not all science networks are created equal, owing to the substantive nature of given fields, and the historical context in which certain disciplines develop (Cole, 1992). This is of particular importance in understanding the asymmetries that exist between national scientific communities. The endogenous structure characterizing First World science is not present in most of the developing world (Sagasti et al., 2003). As a result, resource-poor nations are unable to sustain highly technical fields like their northern counterparts, for example high energy physics and genome projects (Drori et al., 2003). Thus, the general size and quality of developing world networks of science by field cannot be expected to mirror those in the North. Yet a scientist's professional network, whether in developed or developing spheres, provides characteristics to shape the availability and content of new ideas, information, technologies, financial resources, and technical support leading to new collaborations and productivity. Through these means, socio-economic outcomes, professional mobility, and scientific prestige are determined (Cole and Cole, 1973).

Traditionally, scientific networks were structured by institutions of training, employment, conferences, and professional associations, but new information and communication technologies significantly increase the importance of contacts initiated and maintained over the Internet (email, chat, message boards, and personal web pages). The functional equivalence argument proposed by Gershuny (2002), suggested that the Internet can reduce time, space, cost of communication, and information gathering of pre-Internet practices. This reduction is particularly relevant to developing world scientists, who sometimes become structurally isolated from the global scientific community (Gaillard, 1991; Davidson et al., 2003; Sagasti et al., 2003), due in part to the high cost of scientific communication and information, characteristic of the pre-Internet era. With the rise of transnational science collaborations, scholars recently noted the impact of the Internet on global knowledge practices and production (Sproull and Kiesler, 1991, Abels et al., 1996; Wellman et al., 1996; Blume 1997; Walsh and Byma, 1996; Koku et al., 2000; Wellman and Haythornthwaite, 2003; Walsh and Maloney, 2003). These studies generally conclude that the Internet, at least in the developed world, has increased the frequency and geographic range of collaboration, provided equal access to shared information, and ameliorated the coordination problems associated with shared work. Huang (2006), in a study of Taiwanese academics, found that email helped strengthen intra-organizational ties and increase co-authored productivity, but it did not help strengthen inter-organizational cohesion and co-publication.

Since sophisticated network analyses have not been conducted in less developed regions, some science scholars expressed skepticism about reports of positive impacts emerging in Third World regions (Ehikhamenor, 2003). Results from one study even show negative associations between collaboration and productivity and suggest that the Internet may serve to reinforce this pattern (Duque et al., 2005). One possible explanation may lie in varying relationships between local, regional, and global ties among developing world scientists (Shrum and Campion, 2000; Duque et al., 2005). Developing world scientists may opt to pursue international contacts at the expense of local ones, albeit these distant ties may not prove to be useful in accessing complex knowledge (Murray and Poolman, 1982; Hansen, 1999). Geographical heterogeneous ties could magnify coordination problems (Rothschild-Whitt, 1979; Sirianni, 1994) that may, in turn, inhibit productivity (Huang, 2006).

In summary, developing world scientists with greater access to heterogeneous, non-connected, high status contacts could experience increased support and access to new resources. Further, the social networks perspective suggests that researchers could counteract the contextual constraints implicit in homogeneous, resource-poor, isolated networks. Yet transnational heterogeneous networks imply coordination difficulties, suggesting that strong local ties are still vital conduits for the transfer of complex knowledge.

The Internet represents a new avenue for cyber-links, reducing the cost for local contact, while extending the potential for networking far beyond national borders. Therefore, the optimistic view suggests that digitally-connected individuals and organizations may increase both off-line networks and emerging on-line networks simultaneously to compound benefits. To temper this positive assessment, a reading of Chile's recent history indicates that the relationships between technology, social networks, and productivity are shaped to a certain extent by historical global dependencies. However, research visits over the last three years suggest that in Chile, the government, the market, and the greater society support Internet technologies. Free market conditions readily provide technological innovations and support, and a government-financed institute actively maintains a system that networks major universities and research institutes. Unlike the sub-Saharan African experience, perhaps adoption and use patterns in this context may mirror those found in the First World.

1.4 Research Questions

This dissertation research considers theoretical issues in STS, development studies, and social network perspectives to be the foundation for a quantitative and qualitative investigation of the Chilean scientific community within a new digital global environment. The general study hypothesis extends research initiated in the "Collaboration Paradox" in developing areas like Africa and India. That investigation suggested that among scientists, the unsettling relationships between collaboration and productivity may undermine the collaborative benefits of new information and communication technologies (Duque, et al., 2005). More specifically, the theoretical synthesis of these perspectives leads to the following research questions:

1) What social forces have shaped Internet practices within the Chilean scientific community? Recent STS literature suggests that Internet practices in the developing world are more complex than simple notions of "adoption" or "access" (Ynalvez et al., 2005). The diffusion of innovation perspectives remains useful in pointing to sources of inequalities, based on social characteristics (Rogers, 1995). The neo-institutional literature suggests that organizational configurations, scientific fields, and professional career histories may also be important in shaping orientations toward northern technological models (Drori et al., 2003; Fry,

2006). For instance, male scientists trained abroad to work in certain types of fields or organizations, may exhibit greater usage and diversity in their Internet practices.

2) How is the Internet shaping the local and global networks of Chilean scientists? Past STS research, before the onset of the Internet, suggested that there is an inverse association between local and global ties in some peripheral regions (Shrum and Campion, 2000). The Internet often is viewed as a means to create and maintain global relationships in a convenient and cost-effective manner (Gershuny, 2002). If this holds true, new ICTs could mediate an intellectual flight to the developed world, due to low research resources in the periphery and high prestige opportunities at the core (Cole, 1992; Schott, 1993). There is also some suggestion that developing-world researchers in the same field compete for meager local resources and guard jealously the keys to their developed-world research and patron networks. The opportunity to extend international relationships through new ICTs suggests that there is motivation to ignore local networks in favor of global ones (Sagasti et al., 2003). This generally supports the "affliction argument." The three years of investigation into the Chilean case suggests that local researchers actively employ the Internet to manage global contacts, thereby relying on email communications for literature-gathering in their fields. However, researchers also depend on local contacts to share expertise and provide information on employment and research opportunities. This author anticipates that Chilean researchers will increase their international linkages without reducing local linkages. If so, there may be a positive association between local and international contacts, rather than the inverse relationship found in sub-Saharan Africa. This would generally support the "elixir" argument. Finally, technology diffusion tends to favor some social groups at the expense of others. Sub regional differences and gender may impact the availability of resources, Internet practices, and network profiles. If Internet practice is

exclusively associated with greater network reach among male and core located scientists, this may indicate the "affliction" argument.

3) Is the relationship between collaboration and productivity mediated through the Internet? Recent work examined the relationship between collaboration and productivity, with a focus on benefits. Lee and Bozeman (2005) find that for a sample of U.S. scientists, collaboration enhances productivity. Walsh and Maloney (2003) find that email use reduces collaboration problems. This past study shows that although African scholars employ the Internet for international collaboration, such collaborations lead to increased problems of coordinating distributed work across national boarders (Duque et al., 2005). Costs related to increasing collaborative work tend to reduce output where Internet practices diverge from those in the developed world (Ynalvez et al., 2005). Noted earlier, investigation into the Chilean context suggests quite a different experience than that of the African context. If the Internet does produce a relationship between local and global ties as described above, then collaboration may increase research productivity. However, if this productivity is skewed to foreign journals, this may indicate a dependent relationship, supporting at best the "teething" argument.

The following formalizes the interpretation of three possible results:

1. If the Internet is associated with *increased* local and globally oriented scientific activity, less problems reported in research, and networks that are symmetrically domestic and foreign, it suggests an "elixir" outcome.
2. If the Internet is associated with *less* local and global scientific activity, larger foreign networks, and more research problems, it suggests an "affliction" outcome.

3. If the Internet is associated with a *greater* globally oriented scientific activity, more problems in research, and larger foreign networks, only longitudinal data may assess whether this relationship is one of "teething" or "affliction."

The proceeding chapter examines more closely how the various literatures reviewed apply in the Chilean context. This dissertation will then overview the dual methodologies employed.

CHAPTER TWO: THE CHILEAN CONTEXT

Recent Chilean history relates to several perspectives reviewed in the previous chapter; these include dependency, globalization, neo-institutional theories, and the study of technology transfer. From its birth, Chile has participated in the global society, distinguished once for having one of the longest unbroken traditions of democracy in the developing world. This is due in part to historical cultural and economic ties with Europe, North America, and various multilateral organizations. On the eve of a watershed disruption to this unbroken tradition, Chilean culture was very much a mirror image of northern consumer patterns and institutional identities (Kerbo, 1978; Merom, 1990). However, a 1973 coup liquidated the democratically elected Marxist government of Salvador Allende. At that time, Chile embarked on a national restructuring of its economy, emphasizing free trade and consumerism. Today, Chile is one of the leading economies in Latin America and one of the few low-indebted developing nations. Chile enjoys robust trading agreements with its regional neighbors: the United States, the E.U., and the Asian trading block (Holm-Nielsen and Agapitova, 2002; Mullin et al., 2002). Moreover, Chile possesses attractive legal and financial infrastructures, which facilitate foreign investment, venture capital, and trade. These infrastructures have enabled Chile to develop into a regional leader in Internet connectivity and, most recently, in dynamic scientific growth. In this chapter this author looks more closely at the (2.1) historical dependency and globalizations influences in Chile, (2.2) its Internet infrastructures and adoption, (2.3) the Chilean research community's structure and productivity.

2.1 Dependency, Globalization, and Chile

Although Chile's national profile has been elevated by neo-liberal restructuring, its development over the last three decades sparked arguments over whether globalization has erased or shifted Chile's dependency on the North. As much as Chile has made economic strides in the last quarter-century, unlike South Korea it has been unable to diversify its economic profile from that of a primary producer [20] (Evan, 1979; Gereffi, 1994; Holm-Nielsen and Agapitova, 2002).

The benefit has been a solid, competitive advantage as a low added-value supplier to the world. The cost has been the lack of indigenous, export capacity for high added-value manufactured goods. In addition, the country has sacrificed capacity in both information technology and energy industries. Chile is dependent on northern technology, capital, and foreign energy sources. Presently, Chile develops an advanced digital, petrol-based, consumer society that it may not be able to support in the coming decades. Within the developing world, Chile is not unique in this regard. Its steady economic growth over the last thirty years relative to the rest of Latin America, however, provides reason to expect social change. In particular, some predict that the potentially negative consequences of global economic asymmetry may be offset with a science and technology policy reorientation and with a subsequent production and export reemphasis (Holm-Nielsen and Agapitova, 2002). Nevertheless, policy restructuring efforts must overcome historically dependent relationships and processes.

The result of the Chilean research community's global dependency is four fold:

1. Imported innovations within foreign-owned multinational entities—products of a historically dependent economy—impede indigenous researchers in absorption and

[20] One counter intuitive consequence of unequal terms of trade in the Chilean context is its world leading copper industry and its relation to the global price of the dollar. When the price for copper goes up in the world market, the dollar goes down. This increases revenues to the copper industry, but decreases the comparative advantage of Chilean exports that now cost more relative to the dollar. Tax revenue from copper rise, but tax revenue from Chilean export products goes down. Since those employed in the copper industry make up 1% of the Chilean work force and those employed in the export sector make up 80%, the rise in the global copper price results in a net loss to the Chilean economy (Suarez, 2006).

innovation of new technologies for domestic production and export (Holm-Nielsen and Agapitova, 2002).

2. An inability to develop a strong manufacturing sector or an entrepreneurial class reduces the local consumer base for manufacturing and technological research (Holm-Nielsen and Agapitova, 2002).

3. An asymmetric global trade environment subjects Chile to discriminatory tariffs on high added-value exports[21] and dissuades investment in domestic technologies production. This orients research to address primary productions such as mining, fisheries, agri-business, and lumber (Holm-Nielsen and Agapitova, 2002).

4. Lack of policy support and geopolitical disruptions, force or lure local human capital to more lucrative, oft times safer, pastures abroad (Slemenson, 1974; Vessuri, 1987).

Points one through three suggest a structural emphasis on local research and development in primary goods production, perhaps at the expense of research investment in innovative technologies. This emphasis causes a continued dependency on northern innovations capacity and imports. Point four suggests that political instability at home, coupled with rewards abroad and the lure of professional recognition may have encouraged local scientists to seek global over local relevance. As a result, the Chilean scientific community, as in other southern regions, may be "disarticulated" (Vessuri, 1987; Casanueva, 1988) from its policy and economic environment, and structurally isolated from relevant research that might have been applied locally (Holm-

[21] Brazil found itself face to face with this trade policy asymmetry when it attempted to develop an indigenous ICT sector over the last two decades. U.S. policy makers pressured Brazil to reconsider this investment and open its market to northern ICT firms. After a series of direct and indirect trade threats, Brazil inevitably relented (Schoonmaker, 2002).

Nielsen and Agapitova, 2002).[22] Even contemporary research in agriculture leans toward "large production" northern models (Moraga-Rojel, 1989). These last points may be the most troubling and the most challenging for the reorientation of science and technology, considering that outward expectations and modalities are so thoroughly institutionalized within the research sector.

Just as dependency constraints have limited the development of science in Chile, global forces may open external sources of funding and redirecting research. This is due largely to the recent interventionist efforts of multilateral organizations such as the United Nations and World Bank, and development-minded NGOs. For instance, the 1999 Millennium Science Initiative (MSI), a "learning and innovation" project developed by the Chilean Ministry of Planning and funded by the World Bank, emphasizes science and technology issues.[23] It seeks to improve the productivity of researchers and increase opportunities for advanced training and collaboration (Holm-Nielsen and Agapitova, 2002). Science and technology policymakers expect the Internet to facilitate such projects by digitally expanding and restructuring professional networks both locally and globally. This optimism 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 and Martin., 1996; Hicks and Katz, 1996; Cohen, 2000; Melin, 2000; Kiesler and Cummings, 2002; Hinds and Kiesler, 2002). On the other hand, more recent studies suggest positive relationships in northern science between Internet use, professional networking,

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[22] Abbate (2000) suggests that the Internet successfully developed in the 1960s within a collaborative atmosphere among the U.S. government, private enterprise and the academy. This trinity of cooperative innovation has been found lacking in developing regions, where elites in these three sectors often compete for limited resources and are subsequently suspicious of each other (Patterson and Wilson, 2000).
[23] Chile has recently launched a national online library funded by CONICYT, pooling resources from a consortium of universities (Leighton, 2007).

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., 2003; Quan-Haase and Wellman, 2004; Walsh and Maloney, 2003; Lee and Bozeman, 2005). To temper these progressive findings, 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. Chile's stable growth and expanding digital infrastructure over the last decade suggests some advantages though.

2.2 Internet Infrastructure and Adoption

Chile, as one of the leading periphery nations in terms of Internet diffusion, represents the top Latin American nation in the number of Internet providers per capita (Mullin et al., 2000). REUNA,[24] a Chilean networking company formed in 1986, created an email gateway for most of the universities and research centers by 1987 and by 1992 had connected to the Internet. Since that time, REUNA has been a catalyst for Internet awareness and region-wide diffusion. Most recently, former Chilean President Ricardo Lagos emphasized in national addresses that his administration was committed to developing an Internet culture.

[24] REUNA (Red Universitaria Nacional) is Chile's National University Network.

During the last administration, "free software" legislation was proposed, signaling that Chile has joined other Latin American nations in limiting the technological stranglehold of the North (Miller, 2004). To balance any over-optimism, Chile still does not produce or innovate upon new ICTs in quantity for domestic consumption or export, thus limiting its autonomy over the maintenance and upgrading of these crucial technologies. Prior work on African scientific communities suggests that this issue is more complex than it might appear, owing to unique postcolonial histories, indigenous cultures, and present infrastructures and policy arrangements. This last dimension is crucial in understanding limitations in the African context. There, many local scholars complained of the inconsistency and high cost of Internet connectivity, which resulted in lack of confidence and subsequent disuse of the technology.

2.3 The Chilean Research Community: Structure and Productivity

At present, Chile has five national research institutions and 25 primary research universities. It also hosts a multitude of international institutes (Mullin et al., 2000). In the last decade, the research sector reorganized along free market lines, uprooting the existing funding structure that maintained organizational inertia. This reorganization brought a proliferation of regional universities and research institutes, which pitted national research institutes against academic and industrial research arms for funding. Although Chile's funding policy is fluid, resources are tied to results and not necessarily to tradition or professional connections. This orientation results from the lasting legacy of the neo-liberal model implanted over 30 years ago.

Despite innovations in research funding, though, salaries for full-time academics are low (Mullin et al., 2000). It is common that this group earn extra income consulting for industry, government, and international donors, or practicing what one local scholar terms "taxi lecturing"—piecing together enough part time work at a number of universities to make ends meet. Preliminary qualitative interviews in three Chilean regions during June 2004 suggest that this is true for core and periphery university settings within Chile.[25] This also mirrors general findings in the African context. The benefit is that this practice may have allowed academics to build additional network links to industry, government, and other academic institutions. However, this occurs at the expense of pursuing new research opportunities. New ICTs are expected to have a positive influence on time management by streamlining social coordination and information gathering (Gershuny, 2002). This may have application in the Chilean context. Whether the Internet plays a role in reversing or further cementing this inverse relationship— between time spent augmenting income and that spent pursuing research— is still in question. The present study clarifies this relationship by considering how Chilean scientists access and use the Internet and how they divide their professional time.

One historical liability of Chilean universities is that they still offer few doctoral degree programs[26] (Mullins et al., 2000). Thus, Chile continues to depend on northern institutions for the training of scientists. However, an institutional orientation toward the North may divert research efforts from locally relevant science. Framed as a research question: If local scientists trained in the North maintain social networks abroad at the expense of national ties, might that be considered an indication of dependency? Research conducted in the African context generally validates this thesis (Shrum and Campion, 2000). The recent policy reemphasis directing Chilean university scholars to publish in high-impact ISI journals will most likely increase this northern orientation for training and publishing. Across fields, Latin America is not home to many high-impact journals, suggesting that the road to institutional success in the Chilean academic system passes through gatekeepers abroad. Some contend that the result is enhancing

[25] Mullins et al. (2000) suggests a funding bias toward universities and institutes based in the capital city of Santiago over those in the periphery.
[26] Only 64 PhDs were awarded in Chile in 1999 (Holm-Nielsen and Agapitova, 2002).

northern science at the expense of local science (Polanyi, 1969; Sagasti, 1973; Sagasti et al., 2003). In this “decoupled” setting of adopting global institutional norms and practices without support from proper local infrastructures, neo-institutionalism scholars predict unattained goals and squandered resources (Drori et al., 2003).

According to figures from 2002, the Chilean National Council for Science and Technology (CONICYT) reports that 8507 Chilean scientists and engineers[27] produced 2,109 articles. This places Chile fourth among Latin American nations in scientific productivity.[28] Between the years 1981 to 2002, Chilean scholars produced 26,714 publications, or 10.5 percent of the total articles published by the top five Latin American nations.[29] The average publication per researcher over that same time period is 0.24. Since the global diffusion of the Internet in 1994, there has been a steady if modest rise in publications per researcher from 0.26 in 1994 to a high of 0.32 in 2002.[30] This measure is arguably blunt. The present analysis and results from the quantitative arm of this study constitute a more granular investigation, controlling for background, field and sector, while taking seriously known differences between local and international publications (Shrum, 1997). As such, it offers a richer picture of the impact of the Internet on professional activities.

Further support for the foreign orientation of Chilean research is provided by a recent National Science Foundation report (Hill, 2004). Publications in international journals by Latin American researchers have increased 200 percent over the last decade. Chile’s increase was almost 100 percent, although its portion of total Latin American articles published went down from 12 percent to 7 percent. Chile, though, did lead two-fold in publications per million

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[27] Seventy-six percent were from academic departments.
[28] Data compiled by CONICYT and available on its website 2006 http://www.conicyt.cl/
[29] Reports indicate that the top five Latin American nations in terms of scientific output are Brazil, Mexico, Argentina, Chile, and Venezuela.
[30] This is a high among Latin American nations. The other four averaged 0.18 publications per researcher.

inhabitants when compared with Brazil, the most prolific Latin American research community over this period. Region-wide, citations of Latin American published work by outside researchers increased by three fold, [31] while international collaboration among the Latin American research communities and over that same time period rose from 29 percent to 43 percent. International collaboration was suggested to be the major factor behind the increase in co-authorship of Latin American articles. Moreover, close to 40 percent of Chile's co-authorships were attributed to collaborations with U.S. scholars. However, co-authorship data was compiled by bibliometric methods that traditionally fail to reflect accurately collaboration outside the developed world (Gaillard, 1992; Sancho, 1992; Duque et al., 2005). The dramatic increases reported by NSF belie the modest rise in publications per Chilean researcher reported by CONICYT. The increases suggest a shift from domestic to international publication during the world diffusion of the Internet. Could this indicate a knowledge dependency on the North, mediated by Internet technologies?

A final dimension that must be considered is the historical influence of gender on science in Chile. Just 25 years ago, women comprised only 4 percent of the research sector. Within the second decade of the dictatorship, women dramatically reached the 40 percent level. This may be attributed to (a) the growth of the scientific community during an economic upsurge of the 1980s; (b) a vacuum left by qualified males who pursued opportunities abroad after the political disruptions of 1970; and (c) policies encouraging Chilean women to pursue professions in non-traditional fields. Yet in the transition to Democracy during the early 1990s, the percentage of women in Chilean sciences paradoxically dipped to 30 percent from the pre-democracy high. This reduction also occurred during further upsurges in the economy, in tandem with multi-

[31] Chile's relative citation index was second among emerging and developing nations. Citation rates of articles published by Chilean astronomers are the highest among Chilean fields (Mullins, et al., 2000).

lateral policies that further encouraged Latin American women in science. However, the number of expatriated male scientists abroad who returned to Chile after the dictatorship ended may explain part of this decrease. Women constitute only 22 percent of the 2005 sample of Chilean scientists upon which this present study is based. If representative of the scientific community, it reflects a dramatic regression. Whether this figure is an accurate measure will have to be determined when national numbers are calculated for the last four years. The CONICYT data base that this researcher consulted included only to the 2002 figures. If the Internet proves to be the elixir it is expected to be, women in Chilean science could benefit greatly and perhaps regain lost ground.

2.4 Conclusion

Chile presents an interesting opportunity to understand historical dependency and global forces, particularly with respect to ICT diffusion and scientific capacity in the developing world. These have implications as to whether Chile can successfully integrate into the global information society. In some dimensions, Chile reaped benefits—the introduction of new technologies and capital investment has supported the expansion of the research sector. Yet, Chile was constrained from developing research that could have supported growth in the technology and manufacturing sector, which could mean continued dependency upon the North. At present, Chile is a regional leader in Internet adoption and connectivity and enjoys wide social and policy support for diffusion. However, its scientific community has been historically marginalized; a constraint shared with other developing regions, and compounded by historical political disruptions. As a result, it is unclear how the Internet will continue the expansion and reach of Chilean science.

When returning to democracy, free market policies were applied to the research sector, while multi-lateral support has increased the opportunity for international training and collaboration. These seemingly position Chile to benefit from the information society. Although Chile lags in scientific productivity among regional leaders, it leads in per capita output and shows a faster marginal productivity increase during the global diffusion of the Internet. Yet conservative local figures on scientific growth seemed at odds with foreign reports showing dramatic increases in international collaboration and citation. To understand the discrepancy better, the present study synthesizes analyses of Internet access and practice by Chilean scholars with data on their professional networks, as well as their collaboration and publication patterns. The analyses also seriously consider the gender dimension. Results are expected to clarify the relationship between new ICTs and internal and external research asymmetries. In the following chapters, the study reviews the dual methodology employed in this dissertation, followed by analyses and findings.

CHAPTER THREE: SAMPLE AND METHODS

To address the three research questions, this study employed a dual methodological design. A digital video-ethnography was initiated in June 2004. At that time, the study identified key dimensions of the Chilean scientific community and Internet practice. It also uncovered the historical legacy of dictatorship, together with an introduction of the neo-liberal model. The author returned in February 2005 to organize and initiate a comprehensive survey of the scientific community through the use of an instrument employed in Africa, India and the Philippines. The following text will discuss (3.1) the digital video methodology employed. Then there will be (3.2) an explanation of the quantitative phase of the study.

3.1 Video-ethnographic Sample and Methodology

The first research question—what social forces have shaped Internet practices within the Chilean scientific community?—requires a nuanced approach and is addressed through an analysis of video-taped interviews initiated in June of 2004. Digital video ethnography is an emerging sociological methodology that allows the documentation of qualitative interviews in the unmediated voice of those observed, and within their actual work facilities and social settings. During the course of a one-month research visit in Chile, I employed this method in three regions—Santiago, Concepcion, and Puerto Montt—to document the following events and objects:

1. Oral histories and interactive conversations with academicians and researchers, institute administrators and staff.
2. Observations of professional and social activities (research meetings, lectures, Internet use, and social life outside work hours).

3. Archival documents and photos, journals and newspapers (often saved by professionals as they relate to special memories).
4. Research facilities and field sites.

The video interviews with Chilean researchers also included impromptu interactions, as opportunity and custom allowed. The author was able to begin this documentation with 35 hours of videotaping during June, focused primarily on the careers of local scientists. The recent footage from the summers of 2005 and 2006 represents the range of individuals (including the research team), settings, and activities that constitute the Chilean scientific community, its history, and present institutional environment. Preliminary results are presented in a project documentary, "Tale of Two Golpes: The legacy of Dictatorship, Chilean Science, and the Internet," which is included as a visual accompaniment to this written dissertation.

The author's background before entering graduate school was in screenwriting and film acting, and the author has produced and presented digital video work documenting the current project in Ghana and Kenya, and most recently documenting the Katrina Aftermath with colleagues. The author's recent work with Dr. Wesley Shrum has resulted in a paper (Shrum et al., 2005) describing the videoactive context made possible by new digital technologies and the techniques for presenting these materials as a supplement to traditional forms of academic presentation. The team has already produced and presented early work at CERN, two side events at the World Summit on the Information Society in Geneva, and at an annual Society for Social Studies of Science Conference in Paris. The author views digital video as a form of documentation and a presentational resource that will become increasingly important in reaching a broader audience. With the introduction of digital video technology and the reduced cost and complexity of use, the author and his colleagues suggest it is time for sociology to re-evaluate the use of visual mediums in research (Shrum et al., 2005).

The qualitative video phase of the study relied on collaborative arrangements with three Chilean scholars in three distinct locations: Professor Fernando L. Duque, PhD at the Universidad de Los Lagos in Puerto Montt (far south), Professor Omar Barriga, PhD at the Universidad de Concepcion (mid south), and Professor Marjorie Murray, PhD (ABD) at the Universidad Catolica in Santiago (central). All three local collaborators were initially identified through the author's personal and professional networks. During June 2004, these collaborators proved to be most instrumental in scheduling a total of 29 digital video interviews with researchers located in academic departments and research institutes.[32] The research institutes were tied to a major university in the three regions studied. The subjects in the sample represented both natural and social sciences and all had either an M.A. or a PhD in the field. The sample included six female researchers. The subjects' ages ranged from mid twenties to early seventies. The oldest individual in the sample had received a professional degree in the late 1950s, while the youngest was completing a professional degree at the time of the interview. The videotaped interviews of between one to three hours duration were semi-structured and focused on major areas of a respondent's career: (a) professional antecedents, (b) present projects, (c) managing professional networks, and (d) Internet history and practice.

The author conducted all the interviews using a Sony mini digital video camera in conjunction with an external wired lavaliere microphone. All but three interviews were administered in Spanish. All but two of the interviews were conducted in the subject's primary office. Because of the sensitive nature of the questions, the national origin of the study (the

[32] Two of the twenty-nine subjects were contacted over email from the United States. These two worked at university bio-technology center. Over a few email exchanges with the director and his associates, I was able to schedule the interviews with out the assistance of an intermediary.

United States), and the use of a digital video recording device, subjects were free to answer as much or as little as they wished. Few portrayed any alarm. The ones who did completed the interview nevertheless. Those reluctant participants cited the mediation of a trusted colleague as the main reason for their participation.[33] The qualitative phase was an invaluable experience, not only providing a better understanding of historical research context in Chile, but also in developing collaborative relationships with local researchers. The author would rely on this historical context and the contacts made when returning the following year to conduct the survey phase of the study.

3.2 The Communication Network Survey

The second and third research questions concern the relationship between local and global networks and the relationship between collaboration and productivity mediated by new ICTs. The responses to these two research questions are provided by face-to-face survey interviews with 337 Chilean scientists. These interviews were conducted in March and April of 2005, with a follow up visit in June 2006. Survey research is widely considered to be a valuable method of investigating underlying factors shaping socio-technical outcomes of large populations, such as those produced by the global diffusion of Internet technologies (Dutton, 2006). This present study relied upon a communication network survey first developed in 1994 for a study of scientists in Ghana, Kenya, and Kerala (Shrum, 1997; Shrum and Beggs, 1997). The author is very familiar with the instrument, as it was later updated and used to collect the data used in the recent "Collaboration Paradox" paper (Duque et al., 2005). The original survey was executed before the diffusion of the Internet into these regions, while the versions

[33] During the survey phase of the study, we experienced some resistance to the network portion of our questionnaire. Giving lists of professional contacts in the Chilean context proved to be problematic for some of researchers who lived through the 1973 golpe. One vocal subject reminded us that the military regime had used lists of names to imprison, torture, exile and in some cases execute dissidents.

implemented after 1999 include several pages of questions related to the Internet. The 1999 version has been designed as the methodological foundation for a multi-year NSF-funded study of these same areas. Another distinction between the original 1994 and 1999 project involves the sample used. The earlier study sampled 100 researchers in each of three regions in a wide range of academic, research, and NGO institutes. The second phase increased the size to 300 researchers in each region and limited the sample to a select few academic departments and government research institutes. The author's sample and survey delivery method mirrors the project's most recent phase. In the following, this study details (3.2.1) the sampling frame and sample, and (3.2.2) the communication network survey employed.

3.2.1 Survey Sampling Frame and Sample

My 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,[34] and (2) among three regions—Santiago, Concepcion/Chillan and Puerto Montt/Osorno.[35] Due to different distribution patterns by sector, the academic scientists were localized in one region, Concepcion/Chillan, and the research institute scientists were initially distributed across the two regions, Concepcion/Chillan and Puerto Montt/Osorno. The researchers were contacted by an administrative assistant. The administrative assistant first acquired authorization from department or institute directors. Then

[34] 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.

[35] I returned in June 2006 and organized interviews with an additional 37 researchers in Santiago, Chile. Marjorie Murray PhD (ABD), a scholar in the department of Sociology at the Catholic University was instrumental in identifying two additional research assistants who assisted the project.

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 the field or attending an out-of-town conference.

Initially the study accounted for the distribution of fields based on a percentage of researchers in the country working in the following – physical science (physics, chemistry and geology), agriculture science, natural science (biology, forestry, and oceanography), engineering sciences (civil, mechanical, electrical and information sciences) and social sciences (sociology and psychology). Population parameters of researchers by region, sector, and field were compiled with the assistance of online statistical sources that included the Chilean National Council for Science and Technology (CONICYT). For comparison purposes, these numbers were adjusted based on the distribution of fields in the other five regions where the study was ongoing (Kenya, Ghana, South Africa, Kerala and the Philippines). As a result, more emphasis was placed on the agriculture sector, which accounted for over a third of the final sample.

After the initial study, the author discovered a discrepancy in the original goal of equal sampling among research institutes and academic departments. This was due primarily because many of the government research institutes outside of agriculture are based in the capital of Santiago. So in June of 2006, the author returned to Chile and interviewed another 37 researchers located in the capital city to complete the total project sample of 337. The additional interviews did not completely erase the discrepancy, but it did sufficiently minimize the difference to make possible a more persuasive sector analysis.

Table 3.1 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 were 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.[36] The Chilean sample was less likely to be married, 76 percent (line 4), as compared with 89 percent of African and Indian scientists.

Since the postcolonial 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, relying on foreign institutions has resulted from a combination of socio-political disruptions and traditionally few local options for advanced degrees that have shaped an outward orientation for 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%) in our previous study.

The place of training is also represented on Table 3.1. Forty-five percent of Chileans in the sample received a high degree from an institution located in a developed country (line 10).

[36] 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 3.1

MEANS OF BACKGROUND, EDUCATION AND CONTEXTUAL FACTORS

	Mean	N
Background		
1. Gender (% male)	76.6%	337
2. Age of respondent	48	336
3. Married	76.6%	337
Education		
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
Sector		
12. Academic Department	62%	208
13. Research Institute	38%	129
Field		
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
Region of the Country		
19. Santiago (Core)	10.4	35
20. Concepcion/ Chillan (Semi-periphery)	77.2	260
21. Puerto Montt/ Osorno (Periphery)	12.5	42
Research Institutes		
22. Santiago (Core)	26%	35
23. Concepcion/ Chillan (Semi-periphery)	41%	53
24. Puerto Montt/ Osorno (Periphery)	32%	42

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 12). 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 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, the author identified that few domestic doctoral programs are offered across field. 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.

Finally, Table 3.1 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%). By region of the country it was distributed by the following (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.

3.2.2 The Survey Questionnaire

For this phase of the research on the Chilean scientific community, the author used a communication network survey already employed in five other research settings (Kenya, Ghana, South Africa, Kerala in India and the Philippines). Chile is the only non-English speaking nation in the study. Thus, the English language survey used was translated into Spanish over an intensive two-month period in January and February of 2005. It went through three initial drafts with online translation and then two human translations. The local collaborators, Professors Omar Barriga (who is bilingual) and Guillermo Henriquez in the sociology department at the University of Concepcion, as well as the author, finalized the translation a week before the instrument was employed in the field in a line-by-line recheck with the original source. After a day of test interviews, the graduate assistants provided feedback. This information allowed us to fine-tune the instrument even further. Since the instrument was to be administered in a face to face manner, preparing the graduate assistants to respond to requests for clarification and in some cases objections, became a major emphasis over the three days of interviewer training.

The survey included sections on background, professional activities (projects 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 discussed above (tie strength, homophily of inter-organizational and collaborative networks, multiplexity, network size, and a partial measure of range termed here as a *prestige network index*). 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), publications, and network profiles. The survey is understandably limited in accounting for information on all relational nodes within an individual's network. Therefore, analyses in Chapters five and six depend on ego-network measures. Before addressing the quantitative results of the study, the proceeding chapter will discuss major qualitative findings of the study.

CHAPTER FOUR: SOCIAL FORCES SHAPING INTERNET PRACTICE IN CHILEAN SCIENCE

To answer the first research question—what social forces have shaped Internet practices within the Chilean scientific community?— I needed a deep understanding of the historic process in which Chilean researchers learned about, became acquainted with, and employ the Internet in their profession lives. This is addressed through an analysis of video interviews and documentation conducted in June 2004. The videotaped interviews were between one to three hours duration. The interviews were semi structured and focused on four major areas of a respondent's career:

1. Professional antecedents
2. Present projects
3. Managing professional networks
4. Internet history and practice

The career histories, facilities, and activities address a variety of dimensions that describe the process of science in the Chilean context and how the Internet has been adopted and incorporated in professional lives.

The analysis of the video interviews distinguished four key thematic categories: (4.1) Career Paths: the legacy of dictatorship on professional careers and the importance of training abroad; (4.2) Social Networks: the importance of local non-professional ties and professional ties abroad, (4.3) Scientific Practices and Institutional Pressures: the obstacles of transnational collaborations and the effects of requirements to publish in ISI high impact journals; (4.4) the Internet in Professional Lives: in managing professional networks, its benefits to research practices and outcomes, and its use in teaching. The following reviews these categories in depth, followed by a (4.5) conclusion.

4.1 Career Paths

A major theme in many of the interviews revolved around the legacy of dictatorship. Some scholars were displaced as a result of the 1973 golpe. During that tumultuous period, many research departments and institutes were closed for an indeterminate time and the scholars were either demoted or fired.[37] One researcher was imprisoned for eight months by the military junta. Others were exiled or emigrated to research centers and universities abroad in other Latin American nations, the United States, the United Kingdom, or Canada. Those who remained in Chile were obliged to reinvent themselves in the private sector. One actually became a beef speculator for many years, before returning to academia in later life. For those who found opportunities abroad, their career paths took a dramatic turn. Many pursued advanced degrees and found work in universities[38] or multi-lateral organizations like the United Nations. For the ones who joined the UN, the work took them as far as Africa and as near to Chile as Central America. These scholars mentioned that their training (for example in public administration or marine biology) in the developing context prepared them well for a career in the multi-lateral development sector. When asked if these unique opportunities in academic and career advancement abroad made up for the tragedy of leaving their homeland, no one offered an affirmative answer. The scholars appreciated the experiences, but could not say if the experience was for the better or not.

The researchers interviewed did eventually find their way back to Chile to continue their careers. All had kept in contact with colleagues and family in Chile while abroad. All would make short visits to measure the political situation in the decades following the golpe. Two returned during the dictatorship but left, unable to find steady work. Not until after the 1989

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[37] For example, the discipline of sociology functionally ceased to exist in Chile after the 1973 golpe. It was revitalized 20 years later after the end of the dictatorship in 1989.
[38] Most exiled scientists immigrated to North America and Europe.

national plebiscite, ending 17 years of dictatorship, did the scholars consider moving back for certain. On their return, many found the research sector dramatically changed. Using existing contacts, most of the subjects found positions in various departments and reported that their international experience was a formidable calling card. Now more privatized, the rapidly expanding Chilean research sector provided ready employment as well.

The importance of training abroad is highlighted by the experiences of those who emigrated after the 1973 Golpe, but it is just as pivotal in understanding the Chilean context for those who were trained over the last two decades. Chile has traditionally offered few doctoral degree programs. As a result, the road to academic advancement is often through institutions in the North. With very little exception, most of the researchers interviewed sought additional training in universities located in Europe, Canada, and the United States.

These professional and intellectual experiences are worthy of note. Professionally, training abroad enhances career profiles upon return to Chile. Intellectually, training abroad increases the exposure to literature and techniques that are in limited supply locally. As one scholar mentioned, "After my first degree, I had learned about all I was going to learn in this area locally. If I wanted to increase my understanding of my discipline, I needed to go abroad." Most also mentioned the financial limitations in seeking advanced training. Although the recently trained scholars have enjoyed new local sources for funding, traditional sources were exclusively found abroad. Though most sought funds in the exterior, a few were supported by the Pinochet administration through Presidential Scholarships. Having completed a doctoral degree in Spain during the 1980s, funded by one of these scholarships, one female subject eagerly admitted, "I am a Pinochet baby." For many, however, resources available abroad do not always cover all expenses. Some maintained salaries at home universities throughout their study in the exterior. Those who did stay on salary say that it was institutional obligation that motivated their return. However, even those who did not have legal obligations say they felt a moral obligation to return and help build the local capacity of Chile. Also, some mentioned that family considerations brought them home, even though career opportunities abroad were much more lucrative in many instances.

The overall path of this group of researchers reflects an outward dependence. Historically, this was framed by a lack of institutional resources and political turmoil. While the consequences of repression may be fading, the neo-liberal legacy of the golpe is still evident today. The privatization of higher education, coupled with a competitive funding environment, has pitted public and private academic, research institute, and industrial scientists against one another for limited resources. This serves to establish in the present day a competitive relationship among local researchers, which may be further emphasizing an outward orientation on training and collaboration.

4.2 Social Networks

The network profiles of the 28 scholars interviewed varied substantially. The commonality among many career histories was that local non-professionals held strong familial ties or *pitutos*.[39] These *pitutos* were very instrumental toward alerting this group of professionals to career opportunities. This was especially true for those returning from exile. Even the younger scholars mentioned how important it was to have familial contacts in acquiring employment opportunities. One scholar at a top university mentioned that his brother in the public sector frequently alerted him to public consultancy positions. The scholar admitted, "the cost of living is high here and the salaries low. We depend on this extra work to make ends

[39] According to my subjects, *Pituto* is a semi-derogatory word representing the intersection of nepotism and cronyism. It is the antithesis of a merit based system.

meet." Others mentioned paternal colleagues as being instrumental in guiding and opening doors for opportunity, especially those whose fathers also were in the academic field or recently retired. Yet, there is common apprehension in the Chilean culture over the use of *pituto* contacts. The respondents acknowledged this, but candidly explained the value of these informal acquaintances in their professional lives.

Those who trained abroad had more foreign contacts, but the ones who had recently returned were more likely to engage those contacts. Time and distance eventually eroded the international networks of this group of scholars. Yet, the importance of professional ties abroad was most often mentioned in connection with maintaining current literatures, especially mediated by email attachments. With very little exception, all the subjects noted the lack of local library and archive resources. The main avenue for acquiring the most recent literatures in one's field was to contact colleagues in the exterior.

In addition, one scholar mentioned that in seeking post graduate training abroad, she found difficulties in identifying a suitable program due to a lack of international contacts. She said, "It is very difficult to find a program in the United States or Canada if one does not first have a contact in an institution there." She eventually found a program in Spain through a referral from a former Chilean professor. This professor was also able to vouch for her return to Chile after the completion of her advance career, a requirement during the application process.

There was skepticism over membership in professional associations. Many mentioned a lack of relevance and the necessity for political maneuvering that is associated with local associations and conferences. Others noted lack of resources for, and language barriers to, membership in northern associations. Even so, the importance of attending professional conferences was highlighted as a way that many maintained continental ties. This is tempered by a realization that on the whole, the Latin American research community does not enjoy much visibility. This was most evident among the scholars in the natural sciences, who admitted that there were very few important conferences in their field outside those in the North. Those in the social sciences were more optimistic, referring to the many influential associations and conferences available within Chile and Latin America. Most researchers, though, were adamant that the cost of travel and registration was a prevalent obstacle to attending conferences consistently, stating that few local resources exist for this.

4.3 Scientific Practices and Institutional Pressures

Another recurring theme was the importance of projects with collaborators abroad. This was especially emphasized in the natural sciences, since scholarly orientation tends to focus on global relevance. The ability to share expertise and in some instances, materials and funding, makes such collaborations attractive. Chile has enjoyed much attention from research institutes in the exterior especially in environmental sciences and astronomy. Countries like Italy, Belgium, and Germany, have originated local bases in which many Chilean researchers find training and career advancement. The 1973 golpe severely reduced this kind of international collaboration, but the end of dictatorship marked the return of global partners in research. Recently, the main obstacle to transnational collaboration is the Chilean funding structure. Researchers complained about the policy of basing funding upon results. This restriction tends to complicate the sharing of monetary resources with collaborators in the exterior, who exist in a distinct funding environment. However, the experimental spirit of Chilean funding indicates that in the near future these kinds of limitations may be resolved.

On an individual basis, the institutional requirement of publishing in ISI high impact journals for career advancement was a major pre-occupation. Many complained that there were few local or Latin American journals on this list, while others argued most of these kinds of journals are published in English only. This brought up two issues. One issue was the relevance of publishing in English, when local colleagues cannot read one's work, due either to limited subscription resources or lack of English proficiency. The other issue was the pressure to stray from local relevance, and pursue "trendy" research that is attractive to foreign journal editors. One social scientist admitted that although the ISI requirement at his university is flexible, disciplines such as social sciences are at a disadvantage. Another scientist poignantly noted that for the past decade he and his colleagues were so busy reconstructing their department after 20 years of absence (a result of the dictatorship) that conducting original research and publishing simply was not a priority. Now that institutional structures are beginning to recover, this researcher suggested that he can focus on intellectual advancement in the form of attending conferences, grant proposal writing, and submitting papers for publication.

Funding and publication pressure aside, research focus among this group of scholars represented a mixture of local and global relevance. Multidisciplinary, inter-sector, and transnational collaboration thrived in all three regions. Large scale collaboration reflected the social and environmental as well as the economic foci of these regions: aqua-culture and marine ecology in the periphery (Puerto Montt), to the impact of industry on artesian fishing communities in the semi-periphery (Concepcion), to bio-engineering plankton bi-products in the core (Santiago). The bio-engineering effort was most telling in its impact on Chile's potential to exploit local economic resources—the Antarctic seas are a bounty of microscopic marine life—and in so doing, produce research worthy of global reach. As part of an international team, two female respondents, trained in Great Britain and now at a major university research center, are developing an organic laundry detergent composed of plankton protein that may be activated at cold temperatures. For a developing nation like Chile, where energy is at a premium, this is no minor contribution. The successful development of this product could have far-reaching implications throughout the developing world in terms of energy conservation and environmentalism. In addition, this research may create an endogenous model (Sagasti et al., 2003) of globally applied research that could halt the cycle of dependency. In this case, as in the other documented collaborations, both local and global research projects interact in innovating ways to produce relevant applications, as well as energize potentials for scholarly advancement. Just as institutional pressure and lack of funding seemed balanced by locally relevant research and transnational collaboration, the Internet in professional lives reflects a similar dual edge sword effect.

4.4 The Internet in Professional Lives

All of the researchers interviewed had personal computers in their offices.[40] All had had some experience with computers in their training.[41] These researchers either first used the Internet while studying abroad, or adopted its use quickly about 1995, when technology entered the Chilean research community. All had access to the Internet with a fast connection. All spoke of the importance of technology in their work, especially in identifying and retrieving up-to-date information in their field. One researcher admitted, "You do not exist unless you are on the Internet." Another exclaimed, "Extraordinary . . . truly extraordinary!" A few of the older scholars regretted that they did not have access to this technology 30 years earlier. One researcher mentioned that during the tumultuous 1970s in Latin America, he and other colleagues had much of their life's work confiscated during the military takeover of university campuses. The Internet, he mused, would have been helpful in backing up documents. To

[40] The two subjects who were interviewed outside of their offices reported having a computer in their primary office.
[41] The senior researchers had been exposed to computer technology when it was first introduced; and with few exceptions, they adopted its use in some form or another throughout their career.

balance this view, one of the veteran social scientists in the present day found little or no use for the computer or the Internet. He preferred employing a secretary to interface with technology when needed.

While the access, streamlining, and duplication of information attributes of the Internet are important, this present study was most interested in understanding how the professional research networks were managed and shaped in the digital age. Although one scholar mentioned that after the 1973 golpe, email might have facilitated maintenance of contacts with exiled colleagues, it was unclear whether the Internet represented a different use than earlier. Most relevant to the study was whether contemporary Internet use served to divert professional research networks from the interior toward the exterior—an indication of dependency. The quantitative phase of the study hopes to address this issue directly. Digital video interviews were helpful in identifying the context of how this process might unfold. For example, the first interview with a marine zoologist suggested a functional equivalence nature in research and Internet technologies (Gershuny, 2002). In the 1960s the zoologist managed professional networks "the old fashioned way" with pencil, paper, typewriter, and postal stamps. Instead of digital archives, he had volumes of abstracts in his field catalogued at his university library, which listed the major works and scholars abroad. He routinely wrote to these scholars at their universities, asking specific questions about their research and inquired about opportunities to collaborate with them. To his initial surprise, these world renowned scholars replied, and soon he was invited to go abroad to continue his education and share the work he was doing in Chile with the global discipline.

When the Internet was introduced, this veteran scholar simply translated to digital the same kinds of information searches and communications networking accomplished in the pre-digital era. He admitted, “It is a wonderful tool that makes the duration between contacts shorter and information instantaneous,” but he also cautioned about the overwhelming amount of irrelevant information on the net. He added that as a result of the Internet, the journal submission process has been saturated and that the crafts of writing and drawing (once important requirements in his field) were slowly fading in the digital age. Although this scholar had made substantial contacts in the exterior earlier in his career, he returned to Chile in the mid-1970s and never went abroad again. His earlier contacts came to visit and engaged him in collaboration, but over time, his main contacts became local. In this instance, the scholar was successful in searching abroad for contacts before the Internet. The nature of his field and the local limitations demanded that interaction. But after use of the Internet and now close to retirement, this scientist’s main digital objective became information searches. This leads the author to consider whether the Internet presently magnifies the networking process. The answer might pivot on the function of particular fields, professional age, and local resource limitations for researchers.

For the younger researchers who studied abroad, Internet communication allowed them to maintain and in some cases initiate, contacts with key people. These contacts provided access to the archive resources in the exterior. A female subject, who studied the social impact of Internet technologies in Chile, succeeded in making a digital contact in England with a major force in the field; she has since traveled to pursue a doctoral degree with him. In this case, she used the search capabilities of the Internet to find his email address on a university website, and then employed the communication function to send a message—one degree of separation using Internet technology. This example suggests that Milgrim’s (1969) six degrees of separation must be updated in the present digital age. Another scholar admitted that he frequently relied upon a colleague in the exterior to email him journal articles he could not acquire locally due to a lack of institutional resources. Another added that the ability to “google” a key researcher’s website and either make a direct contact or download posted works represented an exceptional advantage of this technology. These last two examples reveal that the Internet is used frequently to circumvent international intellectual property rights: a possible example of Internet reagency (Shrum, 2005).

The Internet’s positive impact on research practices was highlighted in professional lives and as a research tool. Many respondents echoed the obvious benefits, including the Internet’s ability to extend networks and circumvent limitations of local archives and restrictions on global knowledge access. In addition, these individuals mentioned the convenience of sharing information with fellow scholars, registering for conferences (local and international), electronic submission of journal articles, and even the ability to contribute to one’s field as a reviewer for a foreign journal. The latter case highlighted a latent consequence of acquiring a digital presence. One scholar said that he had been approached digitally by a foreign journal editor he had never personally met. This scholar imagined his mentor abroad may have suggested his name, or the editor may have read one of his publications and thought him an able candidate to be a reviewer. The Internet, in effect, may have promoted the global reputation of this scholar without his knowledge.

One of the interview subjects had employed the Internet as methodology. An exiled scholar during the Pinochet years, he became interested in immigration patterns of professionals. When he returned to Chile in the early 1990s, he was eager to learn what had happened to other professionals after the 1973 golpe. He admitted that in the mid 1990s, Chilean funding was unavailable for world travel to interview exiled professionals. Plus his field, sociology, was just being reintroduced as a discipline. National research funds were limited even for high profile disciplines. His response was to "turn to the Internet." At first, the researcher searched online for list-serves of Chilean professionals abroad, joined chat groups, and documented the various interchanges he had on line. He acknowledged to a few chat room participants that he was a researcher, and consequently conducted a number of at-length digital interviews about the experiences of these professionals in the exterior. From these interviews and with collaboration from the university's computer science department, he was able to construct a general online questionnaire. A sample was drawn from the list-serves of professionals identified earlier in the investigation. Over 400 Chilean professionals in 40 different nations completed the immigration survey made available for a one month period on line. The researcher later experimented with chat versus email techniques and with a sub sample from earlier studies. He finally concluded that chat was far more effective in recreating the intimacy of a face-to-face interview. Eventually, content analysis of online newspapers and websites was added to his 'Internet as methodology' toolbox. He is considering adding a webcam to chat sessions to deepen the experience. He concluded that for social scientists in a developing nation, the Internet can be extraordinary due to affordable cost and extensive reach. This example above illustrates the transforming potential of the Internet in addressing global science asymmetries. For example, a researcher in the United States exists within a research funding environment that could have supported an immigration study of exiled professionals abroad. Yet this may not be a relevant question to ask, since the United States has not experienced a Diaspora in exile like the one many developing nations have over the past half century. Paradoxically, this research question is relevant in a developing context, yet resources are rarely available. The Internet, as a cost-effective, methodological tool with global reach, closed the funding gap for this particular researcher. To lend perspective to the success of employing Internet technologies in research, Chile enjoys a well-developed digital network supported by the wider society. In addition, the population sampled in the immigration study reviewed above was composed of professionals with advanced communication and information skills. Furthermore, these expatriated professionals lived in developed nations with superior Internet infrastructures. A similar researcher in Africa, who may be interested in Burundian refugees living within that continent, might not enjoy the same success due to deficiencies in local and region-wide Internet infrastructure. Developmental context matters with regard to employing Internet technologies in this methodological manner.

To a lesser extent, some researchers mentioned Internet impacts on teaching as well. One benefit was the vast resource of Internet material (images and texts) that augmented lecture presentations. Some also mentioned Internet benefits for students: to retrieve information for class projects. However, this benefit was balanced by an apprehension that technology may facilitate plagiarism—a concern that echoes those of educators worldwide.

Generally, the Internet was of great assistance to this group of Chilean scholars. But many of them also admitted the liabilities of this technology that includes too much information, relatively little Spanish language content, and the security risk of being connected. As one scholar pragmatically suggested, “The Internet magnifies the ongoing struggle between security and freedom that frames much of the world’s concerns today.” Another concern was too much dependence on the technology. A scholar who had worked for the majority of his professional life in the pre-Internet era mentioned, “When the net is down, the halls fill with researchers who do not know what to do anymore.” Fortunately, this occurs infrequently; yet it does foreshadow the potential risk of dependence on Internet technology, characterized by a fast paced innovative environment and generational interface glitches. Keeping in step with upgrades and mutating digital threats is a major concern in resource-poor regions lacking indigenous innovation capacity.

4.5 Conclusion

This qualitative stage of the study employed video-ethnographic methods to uncover the context of the Chilean scientific community and what social forces have shaped Internet practices within it. This author was able to engage local scholars to adopt and facilitate the project in order to address some of the ethical issues mentioned in the literature (Horowitz, 1967; Solovey, 2001). Twenty-nine researchers were video interviewed across both social and natural sciences in university departments and research institutes located in three regions. The findings highlight a variety of issues that shape Internet practice: the legacy of dictatorship on career paths, the lack of local resources, the obstacles for international collaborations, and the pressure to publish in ISI high impact journals. Cultural limitations in Chile, like other developing regions, still shape networks in particularistic ways (Fukuyama, 2000; Montener, 2000). However, the legacy of political disruption and recent neo-institutional pressures has redirected research efforts in ways that may be creating unintended consequences (DiMaggio and Powell, 1991; Drori et al., 2003). The road to institutional legitimacy often passes through gatekeepers abroad in terms of advanced training and publications and this could be cementing an exogenous domestic science system (Sagasti et al., 2003). Yet, where historical dependencies may have structurally limited this group of researchers in the past, multi-disciplinary, multi-sector, and multi-national collaboration that exploits comparative advantages could propel them to local and global relevance. These findings support both dependency (Evan, 1979) and modernization (Rostow, 1969) perspectives.

The role of the Internet also portends a doubled edged sword effect. For researchers trained in the pre-digital era, the Internet functionally, and more efficiently, replaces past technological modes used to conduct information searchers and manage networks. This supports Gershuny's (2002) functional equivalence argument. A key advantage for those trained in the pre and post digital eras is the Internet's ability to circumvent local resource limitations and global publication restrictions, perhaps an indication of reagency (Shrum, 2005). However, the recent purchase of online journal data bases by CONICYT and a consortium of Chilean institutions may signal a sharp decline in this practice. The Internet also increases global visibility for geographically isolated scholars. One scholar was located on the Internet and asked to be a reviewer for an international journal. Another was able to digitally locate and ultimately work under a major scholar in her field, who was in England –one degree of separation in this case. This suggests Milgrim's (1969) six degrees of separation argument may need to be re-evaluated in the digital age. In still another example, the Internet enabled a Chilean scholar to conduct an immigration study surveying over 400 Chilean professional expatriates across 40 different nations. This may have not been otherwise possible in a developing nation like Chile, a country with little research funds to offer a study of global scope. These last three findings provide examples of the optimistic globalizing effect of new ICTs (Castells, 2000). On the negative side, the English language-dominated Internet seems to direct attention toward the exterior as it perhaps makes those who use it technologically dependent upon it as well. These both may be indications of the magnetic force of the global science core (Cozzens, 1990), as well as an indication of what Escobar (1995) warns is the northern bias of new ICTs.

Taken as a whole, these 29 interviews confirm a strong connection to the North in terms of training and collaboration. The stories also suggest that the Internet facilitates research practices and perhaps brings relevance to the Chilean scientific community, but at the risk of continuing this northern institutional orientation. The proceeding qualitative observations and conclusions should further illuminate understanding among policy makers regarding how the Internet shapes knowledge production in the developing world. An analysis of survey data follows to clarify the Internet's influence in scientific communication networks, global and local collaborative relationships, and Chilean productivity.

CHAPTER FIVE: INTERNET PRACTICE AND PROFESSIONAL NETWORKS IN CHILEAN SCIENCE

While studies of Internet adoption and use by scientists located in the First World have been consistently positive (Quan-Haase and Wellman, 2002; Finolt and Olson, 1997; Abels et al., 1996; Castells, 2000; Galimberti et al., 2001; Koku and Wellman, 2002; Walsh and Maloney, 2003), the impact within the developing world has yet to be fully examined. To date, only a few comparative studies have examined Internet adoption and use by scientists located in developing areas (Duque et al., 2005, Ynalvez et al., 2005; Ynalvez and Shrum, 2006). Even fewer have investigated the network consequences of Internet use in the knowledge sectors located in these regions (Huang, 2006). This chapter extends previous work by examining the structure of Internet use and its association with scientific networks within Chile, a country that enjoys a well developed Internet infrastructure. The objective is to identify significant associations between background and professional characteristics of Chilean scientists, their Internet practices, and professional networks.

Past studies suggest that within the developing world there exists an inverse relationship between domestic and foreign contacts among scientists (Shrum and Campion, 2000). The negative connotation is that either the network profiles of scientists in developing regions are local or they are global, possibly indicating a disjointed scientific community. One group is characterized as "isolated" because it is exclusively connected to local strong ties. While this group may enjoy the support benefits implied by dense local networks, perhaps it is sacrificing avenues for new knowledge and other resources that accrue to those with diverse weak ties (Granovetter, 1973; Lin, 2001; Burt, 1982). Within the impoverished context of many developing world scientific communities, these valuable resources (specialized knowledge, research grants, and opportunities for publishing) are suggested to flow over links from scientific communities in the exterior. In contrast, the other group may be considered "disarticulated." It is outwardly connected almost exclusively to weak tie relationships in the exterior, and thus enjoys the potential for resources and new information. But, this group may be drawn into international collaborations that more often pursue research that is trendy in the exterior, but not always relevant locally (Vessuri, 1987; Sagasti et al., 2003). In turn, this group may also be sacrificing the benefits of strong ties, which have been found to be beneficial for transferring complex knowledge (Murray and Poolman, 1982; Hansen, 1999; Huang, 2006). The ideal network profile suggests a balance of both strong and weak ties (Uzzi, 1996) or in this case, a balance of domestic and foreign contacts.

This chapter assesses whether Internet use is associated with isolated, disarticulated or balanced network profiles in Chilean science. The results have implications for larger developmental issues. The Internet is of particular interest, because its global diffusion is often framed as a positive catalyst that streamlines many social, organizational, and technical processes (DiMaggio et al., 1999; Castells, 2000; Gershuny, 2002). More specific to developing world science, the Internet could act as the "elixir" that resolves this inverse local/global network relationship mentioned above (Davidson et al., 2003). The Internet may connect the isolated scientist to the global scientific community in a cost effective manner, as it reconnects the disarticulated scientist to local scientific relevancy. Conversely, the Internet is considered by some as a possible "affliction" that may further this asymmetrical domestic/foreign relationship (Escobar, 1995; Henley, 1999; Engelhard, 1999) by allowing a new population of developing world researchers to have immediate and convenient access to the global core, the North. Since prestige and resources are concentrated in the North, the unintended consequences of Internet communication may result in "digital brain drain" of the periphery's best and brightest researchers. In addition, the Internet may never diffuse effectively within developing regions. While researchers in the North take advantage of the Internet to collaborate and publish at higher rates, researchers working in the South by comparison will fall further behind, thus accelerating a global knowledge divide (Shrum and Campion, 2000; Sagasti et al., 2003). A third possible outcome, "teething," predicts that the Internet may be the catalyst for new collaborative links with core institutions. This may result in negative effects in the short term, but then increase local integration, capacity, and productivity in some peripheral regions over time. To address whether Internet use in Chilean science is associated with any of the various network outcomes listed above, in the following, this study (5.1) reviews the concepts and measures employed. Then the study (5.2) explains the analysis and findings, concluding with (5.3) a discussion.

5.1 Measuring Internet Practice and Professional Networks

Throughout the global diffusion of the Internet, measurements of adoption and use have been a contentious issue (Robinson, 2003; Ynalvez et al., 2005). Early studies in the North initially focused on simple access. As the developed world enjoyed Internet saturation, measures have shifted to quality of connection (dial up versus broad band). Now that broad band cable connection has attained prevalence, the discussion shifts to duration and diversity of use. Within many developing world scientific communities, simple access is still not a closed issue. This author's experience in Africa suggests that even in key sectors, connectivity is expensive, slow, and inconsistent. Therefore, for the analysis of data from Africa and India (Duque et al., 2005; Ynalvez et al., 2005), ready access and current use provided relevant measures for comparison. In contrast to this previous study, ready access and current use are not issues in Chile. Chilean scientists are universally well connected. This is credited in large part to three decades of digital network investments in universities and research institutes initiated during the dictatorship of

Augusto Pinochet, coupled with Chile's consistent contact with international technology markets. Thus, the following analyses include only measures of Internet experience and practice. There is one indicator of Internet experience (years using email) and two indices of Internet practice (hours per week using email and email use diversity). Hours using email in a typical week is an ordinal variable measured as 1 = less than one hour; 2 = one to five hours, 3= five to 10 hours; 4 = 10 to 20 hours, 5 = 20 hours or more. Email use diversity is constructed as the sum of dichotomous (1=yes; 0=no) responses to six questions regarding scientists' uses of email. Respondent (a) 'has been a member of science and technology discussion group;' (b) 'has sent a message to such a discussion group;' (c) 'discussed research with someone in a developed country;' (d) 'started a professional relationship with someone met on the Internet;' (e) 'discussed a research proposal with funding agencies;' and (f) 'submitted or reviewed manuscripts for journals.'

To measure network profiles, the use and construct of various measures capture the size, diversity, and prestige index of professional networks: (a) intra-organizational network, inter-organizational network, (b) domestic network, (c) international network, and (d) prestige network index. Size of intra-organizational network is a continuous variable measured by a count of professionals, technicians and doctoral student respondents reported working closely with that are located in their parent organization. To measure the size of their inter-organizational network, graduate interviewers asked respondents to list up to twelve primary professional contacts outside their parent organization by location (local, outside local but within Chile, outside Chile but within South America, in Europe, in the United States and others). This variable was recoded into domestic (inside Chile) and international (outside Chile) contacts. Another measure of size and diversity of networks is a composite count of collaborators over three present projects. Respondents were asked to report the location of collaborators in up to six regions per each of three present projects— local, outside local but within Chile, outside Chile but within Latin America, Europe, United States, and other. Total size of professional networks is measured as a composite count of local (within Chile) and international (outside Chile) contacts. When weighted by geographical dispersion, a composite count of domestic and foreign contacts represents a respondent's network size and reach or their prestige network index.[42] This is measured from 0 to a maximum of 54 (1 = local, 2 = outside local but within Chile, 3 = outside Chile but within Latin America, 4 = Europe, the United States, or other – Canada, Australia, Asia, Africa). Because this variable is positively skewed, it is represented as a natural logarithmic transformation for some of the analyses.

Control variables in this analyses include: Sector, coded as a dummy (0,1) variable with academic scientist as the reference group; Geographic location [43] in the national research community 1=core (Santiago); 2=semi-perhipery (Concepcion/Chillan); 3=periphery (Puerto Montt/Osorno); Field, coded as four dummy (0, 1) variables –agricultural, physical, natural, and social sciences with engineering as the reference group; Gender (1=male; 0=female); Age, measured as an ordinal or continuous variable depending on analysis used; Educational credentials (0=non-doctorate; 1=doctorate); Location of highest degree (0=local, 1=in a developed country); and professional activities and awards, for example, (1) the Number of professional conferences respondent reported attending over the last five years—a positively skewed continuous variable represented as a logarithmic transformation for the analyses; (2)

[42] The qualitative interview identified the high regard my Chilean subjects place on foreign contacts and collaboration. Because local funding is limited and there is pressure to publish in high impact ISI journals, suitable projects require seeking foreign collaborators. Acquiring these foreign contacts and projects is associated with career advancement and prestige.

[43] Due to the wide distribution of research institutes in three regions, the core and periphery represent exclusively research institute scientists. The semi-periphery includes all the university scientists and a third of the research institute scientists. Thus findings by location are limited to variations within research institutes sector.

Total collaborations, an additive count of (0,1) responses of three current projects respondents indicated were collaborative or not; (3) the number of Individual awards, and (4) the number of awards as part of a larger study, or Project awards, that respondents reported receiving in the last five years. These two award variables are positively skewed and represented as a natural logarithmic transformation in the regression analyses.

5.2 Analysis and Findings on Internet Practice and Professional Networks

How are professional networks in Chile shaped by Internet adoption and practice? In the following text, the study presents distributions and bivariate and multiple regression analyses to identify key relationships between Internet access and practice and various network measures controlling for contextual, background, and professional dimensions. Table 5.1 reflects the means description of the entire sample for personal computer (PC) and Internet use and professional networks. Table 5.2 reflects the means distribution of PC and email adoption and use by sector. Significant differences in this table are distinguished by a one way Anova test. Table 5.3 considers contextual, background, and professional characteristics of various email adoption and use patterns. Table 5.4 considers the contextual, background, and professional characteristics of various professional activities and awards. Table 5.5 then considers the contextual, background, and professional characteristics associated with various network measures. Significant differences in Tables 5.3 – 5.5 are distinguished by using a one way Anova LSD post ad hoc means comparison test. In Table 5.6, a correlation of domestic and international contacts is utilized, as well as a Pearson two tail test to determine the significance of this relationship. In Table 5.6, the study performs regression analyses to distinguish the most significant predictors for intra-organizational, inter-organizational network, geographic network diversity, and network prestige index. The study uses three Internet indicators (email age, hours using email, and diversity of use) as independent dimensions and controls for the contextual, background and professional dimensions analyzed in previous bivariate comparisons.

TABLE 5.1

MEANS OF PC AND INTERNET ACCESS, AND PROFESSIONAL NETWORKS

	Mean	N
PC and Internet Access and Use		
1. PC located in office	100%	337
2. Year first used email	1994	336
3. Ready Email Access	100%	335
4. 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
5. Email Use Diversity	4.2	338
Intra and Inter-organizational network		
6. Number of professional scientists within parent organization with whom respondent works closely.	6	335
7. Technicians	1.8	335
8. Doctoral students	0.7	335
9. Total number of doctoral students, professionals, and technicians with whom respondent works closely.	8.5	335
10. Total number of professionals outside organization with whom respondent works closely	4.9	330

Table 5.1 reflects the high level of connectivity and use enjoyed by the Chilean sample. One-hundred percent of the respondents report having a PC in their office (line 1) with ready email access (line 3). The sample reports first using email in 1994, on average two years earlier than the Africans and Indians in a previous study (Ynalvez et al., 2005). The sample reports on an average use of email (line 4) of over 5 hours a week each. Email diversity on average is 4.2 out of six categories (line 5). This is also on an average greater than the Indians and the Africans. On an average, Chilean researchers report working closely with 8.5 colleagues

(professionals, doctoral students and technicians) within their parent organization (line 9), while they work closely on average with 4.9 professionals outside their parent organization (line 10).

TABLE 5.2

MEANS OF PC AND EMAIL USE BY SECTOR

	Academic	Research
PC Use		
1. In a typical week, about how many hours using a PC for job (whether at home or at work)?[1]	4.18***	4.52
2. How comfortable do you feel using PCs in general? (1-very comfortable, 4 not comfortable)	1.42	1.46
Email Use		
3. How many email messages sent in a typical week[1]	3.71**	3.86
4. How many of these are related to research? [1]	3.18***	3.66
5. How many email messages received in a typical week?[1]	3.86**	3.97
6. Hours in a typical week spent sending and receiving email?[2]	2.21***	2.48
Things done using email (1-yes, 0-no)		
7. Has sent a message to an S&T discussion group	50.5%***	64.8%
8. Discussed research with someone in developed countries	85.6%	86.7%
9. Started a professional relationship with someone met on the Internet	40.4%	45.3%
10. Continued email contact with someone met personally	96.6%	98.4%
11. Discussed proposals with funding agencies	53.4%***	68.2%
12. Submitted or reviewed manuscripts for journals	79.3%	82.2%

*** p < .01, ** p <.05, * p < .1
Significant differences reflect a one way Anova means comparison test.
1. 1 = Less than one each week, 2 =Between 1 & 6 in a week, 3 = 1 or 2 daily, 4 = More than 2 daily
2. 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

When comparing PC and email access and use by sector in Table 5.2, scientists in research institutes use their PCs for significantly more hours per week (line 1). Research Institute scientists are also significantly more likely to send (line 3) and receive (line 5) more emails in a typical week, have more of their sent emails related to research (line 4), and spend more hours a week using email (line 6) than do academic researchers. Moreover, those in research institutes are significantly more likely to have sent a message to a science and technology discussion group (line 7), and discussed a proposal with a funding agent using email (line 11). In the previous study, the only functions of Internet communication reported by more than half of the African and Indian users were (1) continuing contact with someone met personally, and (2) discussing research with someone in developed areas (Ynalvez et al., 2005). Chileans reported using the Internet at higher than 50 percent across all dimensions except starting a relationship with someone online. This may result from the reported provincialism of the South Americans. My qualitative interviews suggested that Chileans, like many in the region, are adverse to new things. Although the Internet is no longer a novelty, cyber relationships are considered rather provocative.

So far, the study considers only sector differences in email access and use. Table 5.3 shows significant variations in the Chilean context based on social, educational, and professional characteristics. Specifically, the study presents differences in email adoption and use patterns based on gender, age, marital status, education, and location of high degree as well as by location, sector and field. Location is measured as core (Santiago), semi-periphery (Concepcion/ Chillan), and periphery (Puert Montt/ Osorno).[44] This dimension was distinguished in the literature as shaping resource and expertise flows, favoring the core – the capital city Santiago (Mullin et al., 2000). Column 1 reveals that email experience significantly favors those in the core and semi-periphery over the periphery (lines 1-3), those in university departments (line 4), men (line 7), those in their early and mid career years (lines 8-9), those who have a PhD (line14), and those who acquired a high degree from a developed country (line 15). In general, this

[44] Due to the wide distribution of research institutes in three regions, the core and periphery represent exclusively research institute scientists. The semi-periphery includes all the university scientists and over a third of the research institute scientists. Thus findings by location are limited to variations within research institutes sector.

TABLE 5.3

MEANS OF EMAIL EXPERIENCE, USE AND DIVERSITY BY SOCIAL CHARACTERISTICS

	Years Using Email	Hours Using Email[1]	Email Use Diversity[2]	
	Mean	Mean	Mean	N
Location				
1. Santiago[a]	10.6[c*]	2.68[b**c***]	4.5	35
2. Concepcion/Chilllan[b]	11.14[c***]	2.27	4.1	260
3. Puerto Montt/ Osorno[c]	9.4	2.29	4.2	42
Sector				
4. Universities	11.2**	2.21***	4.0**	208
5. Research Institute	10.3	2.48	4.4	129
Field				
6. Agricultural Sciences[a]	10.0[bd***c**]	2.24 [d**]	4.2	114
7. Physical Sciences[b]	11.9	2.42	4.1	38
8. Natural Sciences[c]	11.1	2.26	4.4	99
9. Engineering Sciences[d]	11.9	2.54	4.0	52
10. Social Sciences[e]	10.7	2.24	4.0	34
Sex				
11. Female	10.1**	2.33	4.0	76
12. Male	11.1	2.29	4.2	258
Age				
13. 20 years to less than 35 years[a]	10[bc***]	2.12	3.9	40
14. 35 years to less than 50 years[b]	13[c***]	2.31	4.3	133
15. 50 years and above[c]	12	2.20	3.9	112
Education				
16. Non-PhD	9.9***	2.28	3.7***	143
17. PhD	11.6	2.34	4.5	194
High Degree from a developed country				
18. No	11.3***	2.27	3.96***	182
19. Yes	12.6	2.36	4.46	155

*** p < .01, ** p <.05, * p < .1

Significant differences reflect a one way Anova LSD post ad hoc means comparison test. Letters (a, b, c, d, e) after means indicate specific differences between groups.

1. Time using email is measured as 1 = less than one hour; 2 = one to five hours, 3= five to 10 hours; 4 = 10 to 20 hours, 5 = 20 hours or more.

2. Email use diversity index ranges from 0 (no diversity) to 6 (high diversity).

mirrors a previous study in Africa and India, where those with greater Internet experience tended to be men with doctorates, who acquired a high degree from a developed county, and who are involved in professional organizations.

The second column in Table 5.3 reflects that hours using email in a typical week vary only across contextual factors. Those working in the core (line 1) and in research institutes (line 2) significantly use email for more hours in a typical week. By field, the only distinction was among agricultural scientists and engineers (line 6 and 9), the latter using email for more hours in a typical week. There is no significant variation in the hours of email use by background or professional factors, suggesting an equitable distribution across social factors. The third column of Table 5.3 shows significant bivariate differences among Chileans researchers with regard to email use diversity. Working in a research institute (line 4), possessing the PhD (line 13), receiving the high degree from a developed country (line 15), and reporting membership in a professional organization (line 17) significantly distinguishes those with more diverse email use in Chile. Paradoxically, academic scientists in Chile are more likely to have adopted email earlier (column 1, lines 4 and 5), even though they use email in significantly less diverse ways than do research institute scientists (column 3, lines 4 and 5). In general though, similar differences in email use diversity existed in a previous study in Africa and India and tended to favor male scientists in relatively advanced locations (i.e., Kerala and Kenya), those with better education, who had been trained in developed country, and those who reported membership in a professional association. Distinctively, gender plays no role in email use diversity among Chilean scientists, unlike in other regions studied (Ynalvez et al., 2005).

Table 5.4 reflects the bivariate means distribution of professional activities and awards by social characterizations. The dependent variables here are suggested to vary across different dimensions to influence the network structures of researchers. Column 1 represents the significant differences associated with attending professional meetings. Natural scientists are more likely to attend meetings than engineers and social scientists (lines 8-10). Mid career researchers attend more than early career scientists (lines 11-12). Those with PhDs significantly attend more professional meetings (line 17 and 18). In column 2, collaboration is significantly more frequent in the periphery than the semi-periphery (lines 2 and 4), among those in research institutes (line 5), for agricultural scientists over physical scientists and engineers (lines 6, 7 and 9), and natural scientists over engineers (lines 8 and 9), and mid-career over late-career researchers (lines 13-15). In column 3, individual grant awards are significantly more prevalent among those in research institutes (line 5), male over female researchers (line 11 and 12), and mid and late-career over early-career scientists (lines 13-15). In column 4, grants as part of a larger project are significantly more awarded to periphery than to semi-periphery scientists (lines 2 and 3), those in research institutes (line 5), researchers in agricultural and natural than engineering fields (lines 6, 8 and 9), and counter-intuitively to female over male scientists (lines 11 and 12).

In interpreting these results, it is clear that Internet practice and professional activities and resources, which may shape networks, vary along contextual, background and professional dimensions. Unlike Internet adoption and practice, the periphery is not at a disadvantage in terms of collaborations and resources. Consistently though, research institute scientists enjoy greater Internet intensity and diversity, as well as more collaborations and resources. Although agricultural scientists lag in Internet indices, they are leaders along with natural scientists in collaborations and resources. Men do have the advantage in early adoption of the Internet, but individual awards, sharing an award as part of a larger project is an advantage for female

TABLE 5.4

MEANS OF PROFESSIONAL ACTIVITIES AND AWARDS BY SOCIAL CHARACTERISTICS

	Professional Meetings Attended	Collaboration Frequency	Individual Awards	Project Awards	
	Mean	Mean	Mean	Mean	N
Location					
1. Santiago[a]	6.0	2.3	3.5	2.4	35
2. Concepcion/Chilllan[b]	7.9	2.0[c***]	2.7	1.9[c**]	260
3. Puerto Montt/ Osorno[c]	9.7	2.7	3.8	2.9	42
Sector					
4. Universities	7.6	1.9	2.6	1.6	208
5. Research Institute	8.6	2.4[***]	3.5[**]	2.9[***]	129
Field					
6. Agricultural Sciences[a]	8.1	2.3[bd***]	3.1	2.1[d**]	114
7. Physical Sciences[b]	7.3	1.8	2.8	2.3	38
8. Natural Sciences[c]	9.4 [de**]	2.1[d**]	2.9	2.7[d***]	99
9. Engineering Sciences[d]	6.7	1.8	3.3	1.1	52
10. Social Sciences[e]	6.5	2.1	2.2	1.7	34
Sex					
11. Female	7.9	2.1	2.2[**]	2.8[**]	76
12. Male	8.1	2.1	3.2	1.9	258
Age					
13. 20 years to less than 35 years[a]	5.9[b**]	2.2	1.5[b**c***]	2.1	40
14. 35 years to less than 50 years[b]	8.7	2.2[c**]	3.2	2.1	133
15. 50 years and above[c]	8.3	1.9	3.0	2.0	112
Education					
16. Non-PhD	7.0[**]	2.1	2.6	1.9	143
17. PhD	8.7	2.1	3.2	2.2	194
High Degree from a developed country					
18. No	7.8	2.0	2.9	2.1	182
19. Yes	8.2	2.2	3.0	2.1	155

*** p < .01, ** p <.05, * p < .1
Significant differences reflect a one way Anova LSD post ad hoc means comparison test.
Letters (a, b, c, d, e) after means indicate specific differences between groups.

this does not translate into greater intensity and diversity of use. Although they lead in scientists. Age has a somewhat curvilinear effect on Internet adoption, but experience is clearly an advantage in attending professional meetings and winning individual awards. Collaboration, however, is more a mid-career choice. Finally, Internet adoption and diversity favored those with advanced training and those who acquired a degree in a developing country. With the exception of attending more professional meetings though, these educational dimensions did not affect collaborations and resources. Next, the study directly considers the associations between my various network measures and social characteristics.

TABLE 5.5

CORRELATION OF DOMESTIC AND INTERNATIONAL NETWORK

	Domestic Network	International Network
Domestic network	1	
International network	-.311**	1

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

Before presenting the findings on domestic and international networks by background and contextual factors in Table 5.6, it is appropriate to report the correlation of these two measures to address the inverse relationship in domestic/international contacts as suggested in the literature. Table 5.5 demonstrates a Pearson Correlation two tailed test, which confirms the inverse relationship. Domestic networks among Chilean scientists are negatively correlated with their international networks. Those researchers with more domestic contacts have fewer foreign ones. Conversely, those researchers with many foreign contacts have few domestic ones. This mirrors the relationship found in sub-Saharan Africa (Shrum and Campion, 2005), and suggests that the Chilean scientific community is disjointed and perhaps characterizes an exogenous scientific community (Sagasti et al., 2005).

To understand more clearly the implication of Table 5.5, in Table 5.6 the study presents bivariate differences in intra-organizational, inter-organizational, domestic and international networks, and prestige network indices in the Chilean context. Column 1, lines 4 and 5, reveal that intra-organizational networks are only significantly different across sector and field. Respondents in research institutes report working closely with almost twice the number of colleagues in their parent organization than do academics (line 1). This is intuitive, since academic researchers frequently work on smaller projects with graduate students. In addition, agricultural scientists tend to work closely with more colleagues within their organization than do other fields (line 6). By contrast, external networks differed along five contextual, social, and professional dimensions. The semi-periphery reported less inter-organizational contacts than the other two locations, but only significantly less than the periphery (lines 1 and 3). University scientists report significantly fewer inter-organizational contacts than those in research institutes (lines 4), and agricultural scientists report significantly more inter-organizational contacts than other fields (line 6). Finally, females report significantly fewer inter-organizational contacts (lines 6), while those with a PhD reported a larger inter-organizational network (line 13).

Enjoying a larger domestic network (column 3) is significantly associated with the core over the semi-periphery and the periphery over the semi-periphery (line 3), those in research institutes (line 4), those working in agricultural sciences (line 6), and those who do not hold a PhD (line 13). Enjoying a larger international network (column 4) is significantly associated with age, favoring mid career and older scientists (lines 8 – 10), natural scientists than social scientists (line 8), holding a PhD (line 13), and those who acquired a high degree from a

TABLE 5.6

MEANS OF NETWORK DIVERSITY AND PRESTIGE NETWORK INDEX BY SOCIAL CHARACTERISTICS

	Size of Intra-organizational Network	Size of Inter-organizational Network	Size of Domestic Network	Size of International Network	Prestige Network Index	
	Mean	Mean	Mean	Mean	Mean	N
Location						
1. Santiago[a]	10.0	6.2	4.2[b]**	1.9	6.4[c]**	35
2. Concepcion/Chilllan[b]	8.1	5.7 [c]**	3.1[c]***	2.6	6.9[c]***	260
3. Puerto Montt/ Osorno[c]	10.3	7.0	4.7	2.2	10.4	42
Sector						
4. Universities	6.5***	5.7**	3.1***	2.6	6.1***	208
5. Research Institute	12	6.4	4.1	2.3	9.0	129
Field						
6. Agricultural Sciences[a]	10.8[bd]***[e]**	6.6[d]***[be]**	4.2[b]***[cd]**	2.4	8.0	114
7. Physical Sciences[b]	6.6	5.4	2.6	2.8	7.1	38
8. Natural Sciences[c]	8.4 [d]***	6.0	3.2	2.8 [e]**	7.94	99
9. Engineering Sciences[d]	5.4	5.2	3.1	2.2	5.5 [ac]**	52
10. Social Sciences[e]	8.0	5.3	3.3	1.9	6.6	34
Sex						
11. Female	7.4	5.3**	3.1	2.2	7.2	76
12. Male	8.9	6.1	3.5	2.6	7.4	258
Age						
13. 20 years to less than 35 years[a]	7.7	5.5	3.8	1.7[bc]**	6.4	40
14. 35 years to less than 50 years[b]	8.4	5.7	3.1	2.7	8.5[c]**	133
15. 50 years and above[c]	7.1	6.1	3.5	2.5	6.4	112
Education						
16. Non-PhD	9.4	6.0	4.2***	1.8***	5.9***	143
17. PhD	7.9	5.9	2.9	3.0	8.3	194
High Degree from a developed country						
18. No	8.3	5.6**	3.6	2.0***	6.3***	182
19. Yes	8.8	6.3	5.3	3.0	8.6	155

*** p < .01, ** p <.05, * p < .1
Significant differences reflect a one way Anova LSD post ad hoc means comparison test.
Letters (a, b, c, d, e) after means indicate specific differences between groups.

developed country (line 15). The last two figures reflect a greater than 50 percent difference in the size of international network. Training abroad and acquiring a PhD are globalizing catalysts for scientists in Chile. Close to fifty percent of PhDs are acquired in the exterior, possibly explaining part of the inverse relationship found in Table 5.5.

Finally in column 5 in Table 5.6, the size and reach of a respondent's network (prestige network index) is the most variable with six significant differences out of seven contextual, social, and professional dimensions. Those in the periphery counter-intuitively have a higher prestige network index when compared to those in core and semi-periphery (lines 1-3). This may be explained by the girth of international research resources dedicated to the booming salmon farming in the south and the increasing environmental consequences. Additionally, research institute scientists enjoy a greater prestige network index (line 5), as do agricultural and natural scientists over engineers (line 9). Mid-career scientists have an advantage over those who are late in their career (lines 8-10). Intuitively, those with the PhD (line 13) and those with their high degree from a developed country (line15) also enjoy a greater prestige network index. Next, this study considers the impact of the Internet on networks, controlling for background and professional characteristics.

To identify the most significant factors explaining various network profiles, Tables 5.7 presents tandem regression models for each network dimension— intra-organizational, inter-organizational, domestic, international, and prestige index. Because their distributions are positively skewed, this study employs a natural logarithm transformation for a self-reported number of intra-organizational contacts and the composite variable prestige network index. For field, engineering sciences is used as the reference group. The odd numbered models consider the effects of contextual, background, and professional variables alone. Because their

TABLE 5.7

REGRESSION OF CONTEXT, BACKGROUND, AND INTERNET USE ON NETWORK DIVERSITY AND PRESTIGE

	Size of Intra-organizational Network [a]		Size of Inter-organizational Network		Size of Domestic Network		Size of International Network		Prestige Network Index [a]	
	1	2	3	4	5	6	7	8	9	10
Context										
1. Location	.050	.058	.051	.055	.066	.055	-.008	.012	.068	.086*
2. Research institute	.224***	.215***	.013	-.035	.065	.058	-.073	-.130**	.202***	.203***
3. Agricultural sciences	.253***	.278***	.112	.099	.106	.068	.004	.033	.163**	.217***
4. Physical sciences	.038	.040	.012	.005	-.017	-.021	.026	.022	.021	.026
5. Natural sciences	.144*	.161**	.052	.053	-.014	-.034	.081	.107	.072	.095
6. Social Sciences	.130**	.137**	-.014	-.028	.016	.004	-.049	-.053	.113*	.127**
Background & Education										
7. Gender (male)	.089*	.090*	.111**	.116**	.111**	.116**	.002	.001	.017	.911
8 Age (years)	.046	.048	.021	.043	-.028	-.028	.056	.085	-.075	.191
9 PhD	.049	.047	-.121**	-.134**	-.253***	-.239***	.156**	.119*	.041	.899
10. High Degree from a developed country	-.024	-.033	.133**	.121**	.016	.031	.174***	.140**	.123**	.108
Professional Activities and Awards										
11. Number of conferences attended [a]	.044	.035	.122**	.088	.054	.066	.100*	.039	.116**	.084
12. Total Collaborations	.095*	.094	.129**	.153***	.005	.022	.152**	.162**		
13. Individual Awards [a]	.096*	.086	.130**	.115**	.122**	.141**	.041	-.005	.109**	.067
14. Project Awards [a]	.101*	.095*	.151***	.131**	.216***	.224***	-.065	-.104*	.260***	.234***
Internet Factors										
15. Number of years using email		.043		-.109*		-.120**		.002		.194***
16. Hours using email in a typical week		.074		.101*		-.032		.174***		.044
17. Email use diversity		-.010		.134**		.003		.187***		.052
18. R^2	.196	.202	.171	.201	.167	.181	.154	.219	.235	.273
19. N	326	325	326	325	326	325	326	325	326	325

*** p < .01, ** p <.05, * p < .1

a. Variable is expressed as a logarithmic transformation distributions are positively skewed, this study employs a natural logarithm transformation for the self-reported number of conferences attended, individual awards, and project awards. The even numbered models introduce three Internet factors—email age, time using email, and email use diversity.

Column 1 provides standardized regression coefficients and levels of significance for a model that explains with seventeen factors, almost 20 percent (R^2 = .196) of the variation in size of intra-organizational networks. Model 1 demonstrates that working in a research institute (b = .224), in the fields of agriculture (b = .253) natural sciences (b = .144), and social sciences (b = .130), being male (b = .089) collaborating with more frequency (b = .95), and winning more project awards (b = .101) are significantly associated with a larger intra-organizational network. Except for total collaborations and individual awards, these significant relationships hold when the study introduces three Internet controls in column 2. Internet has no effect on intra-organizational networks, but context and professional activities and awards do have an effect.

Models 3 and 4 reflect the significant variables associated with inter-organizational networks. In the first of these models, the gender effect is again significant (b =.111), favoring men. Holding a PhD is significant and negative (b = -.121), while acquiring a high degree from a developed country is significant and positive (b =. 133). This interesting inverse relationship between advanced education and location of training reflects the bivariate association in Table 5.6 (lines 16 – 19). Close to 50 percent of PhDs are acquired outside Chile, yet the association of about variables with inter-organizational networks moves in opposite directions. This paradoxically suggests that less education, but more international exposure to training benefits networking outside one's parent organization. In addition, attending conferences (b = .122), collaboration frequency (b = .129), and both individual (b = .130) and project grant awards (b = .151) are significantly related with larger inter-organizational networks.

All except one of these significant relationships hold when the study introduces Internet factors in model 4. Attending conferences are no longer a significant predictor of inter-organizational networks, while all three of the Internet factors emerge as significantly associated. Two of these, hours using email per week (b = .097) and email use diversity (b = .133), are positive, while email experience is negative. Those who have less experience using email significantly have larger inter-organizational networks. The findings together are paradoxical, since those who enjoy larger inter-organizational networks significantly tend to use email for more hours in a week and use it more diversely. The education and Internet contradictions may result from the fact that this network variable includes both international and local contacts outside one's parent organization. Although peculiar, these are the first empirically determined finding with controls that link the Internet and professional networks in Chile, but they are not the last. Next, the study disaggregates the inter-organizational variable into domestic and international components.

Models 5 through 8 directly address the major issue of this dissertation: How is the Internet associated with geographic networks of developing world scientists? Past studies have suggested the isolation of developing world scientists to the periphery (Gaillard, 1991; Shrum and Campion, 2000). Other studies suggest the "patrifocality" of female scientists found in traditional cultures like India (Gupta and Sharma, 2002; Campion and Shrum, 2003), and relatively low levels of foreign contacts among researchers in India (Duque et al, 2005). The previous correlation in Table 5.5 confirmed an inverse relationship between domestic and international contacts, suggesting that the Chilean scientific community may be disjointed among either isolated or disarticulated scientists.

Models 5 and 6 indicate a profile for the locally integrated scientist. In the first model, being male (b = .111), and not holding a PhD (b = -.253), and having acquired both more individual awards (b = .122) and project awards (b = .216) are significantly associated with a larger domestic network. The findings on gender and education are intuitive in the Chilean context, where traditional gender roles are still relevant, and at least 50 percent of Chilean scientists sampled pursue a PhD abroad. If having larger local networks is an indication of being marginalized to the periphery of global science, the isolated scientist is more likely male, does not hold a PhD, and yet counter-intuitively tends to be well-funded. When Internet controls are included in Model 6, these three predictors remain significant, while email age is significant and negative. Those who have adopted the Internet later may not have nurtured an international network as much as those who have more experience with it. Local relationships may be more important for this group of scientists, and these can be contacted at a relatively equal cost using traditional forms of communication (face to face, fax, or phone). Moreover, this also suggests that the isolated scientist is a later adopter of the Internet.

International networks in Models 7 and 8 reflect consistent findings with or without Internet controls. This time though, holding a PhD (b = .156) is highly significant, as is acquiring a high degree in a developed country (b = .174). Also highly significant is the collaboration frequency (b = .152), while attending more professional conferences (b = .100) is marginally significant. When Internet controls are introduced in Model 8, the sector emerges as significant (b = -130), favoring academic scientists. Academic scientists have larger international networks than research institute scientists do. The PhD is still significant (b =

.119), as is acquiring a high degree from a developed country (b = .140). Total collaborations (b = .162) continue to be a highly significant predictor of larger international networks, while awards as part of a larger project emerges as marginally significant and negative (b = -.104). This is very counter-intuitive, as the qualitative interviews suggested that funds for any project tended to originate abroad. Finally, two of the three Internet factors emerge as highly significant: hours using email (b = .174) and email use diversity (b = .187). Taken as a whole, this suggests a profile for disarticulated researchers: academic scientists with advanced training from a developed country, who collaborate more, are less funded, and who depend on the Internet for a variety of professional processes.

In the final two models represented in Table 5.7 (columns 9 and 10), prestige network indices are considered. In the first model, working in a research institute (b = .202), working in an agricultural field (b = .163) or in social sciences (b = .113), acquiring a high degree in a developing country (b = .122), attending more professional meetings (b = .116), and both individual (b = .109) and project (b = .260) awards are significantly associated with a greater prestige network index. The first finding is intuitive and confirms the institutional reality that when research institute scientists do not have to divide their research focus with training students, they have more opportunities to expand their network reach. The next two findings are also intuitive. Training in developing countries and attending more conferences provide opportunities for researchers to create a global presence. Enjoying more grant awards translates into resources with which to attend international conferences and attract collaborators.

When Internet controls are introduced in Model 10, being further from the core (b = .86) emerges as significant, but working in a research institute (b = .203) remains a significant predictor of a greater prestige network index. The first finding reflects the rather counter-intuitive results in bivariate Tables 5.3, 5.4, and 5.6. The literature suggests that prestige in the Chilean context in terms of resources tend to be concentrated in the core (Santiago) at the expense of the periphery—Puerto Montt (Mullin et al. 2000). Perhaps the intense research focus in the south, where an emerging global aqua-culture economy is being nurtured, may explain this. To continue with Table 10, working in agricultural (b = .217) and social (b = .127) sciences increase in significance. But once Internet controls are introduced, acquiring a high degree from a developed country and attendance at more conferences are no longer significant predictors of prestige network indices. Having more project awards continues to be highly significant (b = .234), while individual awards are no longer significant. Only one Internet dimension, email age (b = .194), emerges as positive and highly significant, confirming the consistent influence the Internet displays on the professional networks of Chilean scientists. The profile of prestige, a variable weighted to foreign collaboration, is dependent on an Internet dimension much like having a larger international network. Online science, in the Chilean context, is more often international science, and this may indicate a disarticulation of those scientists who depend on digital resources.

5.3 Conclusion

Unlike the low figures reported in other developing regions, Chileans are digitally connected at over a 99 percent level. Chileans do, however, report internal variability of Internet use, diversity, and experience across contextual and background characteristics. Although Chileans adopt email later than academic researchers do, scientists working within Chilean research institutes tend to be more digitally intense and diverse in usage. This supports the organizational literature suggesting that steep traditions characterizing the academy may inhibit change (Scott, 1998), or in this case, adopting various Internet practices. Professional activities and resources also vary across institutional, regional and social dimensions. The periphery enjoys some advantages, as do those in research institutes, while gender is split in terms of grant awards. Males show an advantage in winning individual awards, while women share a greater portion of awards attained as a part of a larger project.

Along the network dimension, it was determined the Chilean scientific community may be disjointed among isolated or disarticulated researchers, an exogenous network configuration found in other developing regions (Shrum and Campion, 2000; Sagasti et al. 2003) –an indication of dependency. Across contextual dimension, those working in Chilean research institutes enjoy more intra-organizational and inter-organizational contacts, more domestic contacts, and have a greater size of scope or prestige network index than university researchers. Clearly, institutional setting is an internal factor in Chilean science along both Internet and network dimensions. Research institute scientists in the semi-periphery report fewer intra-organizational contacts, fewer domestic contacts. Yet counter-intuitively, study measurements indicate that the periphery reflects greater size and reach of professional networks. The periphery also reports greater Internet diversity, when compared with the semi-periphery and the core. Region of the country (core, semi-periphery, and periphery) is a factor for those Chilean scientists working in research institutes only, but suggests a curvilinear relationship with respect to networks dimensions.

As expected, having an advanced education and a high degree from a developed country (a) significantly increased the number of international contacts, and (b) is associated with greater size and reach of professional networks. Also as expected, women report fewer overall inter-organizational contacts; but aside from this there are no significant differences across the gender dimension. Gender plays no role in determining the size of one’s international network or their prestige network index. This indicates that Chile is not subject to the same "patrifocal" pressures that characterize Indian women scientists (Palackal et al. 2006). In general, these findings by gender and region suggest that in the modern era, science in Chile is converging along more equitable lines; and if related to Internet adoption and use, this does support modernization and globalization arguments (Castells 2000).

To detect whether these bivariate relationships hold, a series of regression models were run to distinguish the most significant associations between key contextual, background, and professional factors with various network measures. Without controlling for Internet dimensions, one predictor that appears in all five models is project awards. It is positive in four (intra, inter-organizational, and domestic networks and the prestige network index) and counter-intuitively negative in one (international network). Individual awards are significant and positive in four of five models: intra and inter-organizational networks, domestic networks and prestige network index. Total collaboration is significant and positive in three of four models: intra and inter-organizational networks and international networks. Attending professional meetings is found to be significant and positive in three of five models: inter-organizational networks, international networks and the prestige network index. Having a PhD is significant in three of five models, with two of the three representing a negative relationship (inter-organizational and domestic networks) and with one positive (international networks). Having a degree from a developed country is significant and positive in three of five models: inter-organizational networks, international networks and the prestige network index. Gender is significant and positive in three of five models as well (intra and inter-organizational networks and domestic networks) and favors males. Sector (research institute) is only significant and positive in two of five models (intra-organizational networks and prestige network index). Field is significant and positive in two of five models (intra-organizational networks and prestige network index), and favors agricultural and social scientists. Finally, location in the research community is significant and positive in only one of five models (prestige network index), favoring the periphery.

When adding Internet controls, however, the most consistent factors explaining network profiles are Internet dimensions. In four of five models presented, Internet variables are significant. In two models, email experience is negatively associated (inter-organizational and domestic networks). In the final model for prestige network index, email experience is positively associated. The remaining Internet dimensions are significant in two models. Hours using email and email diversity are significant and positively associated with inter-organizational and international networks. This supports the contention that Internet technologies are associated with institutionally and geographically extended science links (Sproull and Kiesler, 1991; Wellman et al., 1996; Walsh and Byma, 1996). Further, in three models, Internet controls tend to cancel out the significance of attending conferences (inter-organizational networks, international networks and the prestige network index). In one model they cancel out the significance of acquiring the high degree from a developed country (prestige network index). These findings support a structural equivalence argument (Gershuny, 2002) that the Internet may be replacing past modes of networking. This is not a minor finding in a region that reports ambivalence in attending international conferences, due to expense and lack of relevance. In two models, adding Internet controls results in two previously unrelated factors that emerge as significant. The research sector is also significant and negatively associated with international networks, yet shown to benefit academic researchers, while region of the country is significant and positively related to the prestige network index, thereby benefiting those in the periphery.

These findings support the bivariate results that the Internet is having varied influence by institutional setting and region.

Addressing the major issue of this dissertation –the relationship between domestic and international networks –having a PhD is significantly associated with less domestic and more international contacts, even when controlling for Internet factors. Since over 50 percent of Chilean PhDs are acquired from institutions in the exterior, this suggests a mechanism (training abroad) for an inverse relationship between domestic and foreign contacts, alluded to in the literature (Shrum and Campion, 2000). This is confirmed by a significant and negative correlation of these two variables in Table 5.5. Moreover, Internet factors are positive and significantly associated with international contacts, but negatively associated with domestic ones, suggesting the Internet provides a bridge for foreign networking, but not necessarily local networking. This is a finding with consequence if it can be argued that local contacts are more likely to be, or transform into, strong ties more so than international ones. With regard to knowledge production, research suggests that strong ties, rather than weak ties, are the focal avenues for transferring scientific information (Murray and Poolman, 1982). This is especially relevant to complex knowledge transfers, where weak ties may actually hinder and not facilitate access (Hansen, 1999). Research also suggests that some combination of weak ties (access to innovation) and strong ties (access to complex knowledge) is beneficial, especially in determining organizational outcomes (Uzzi, 1996). Should the Internet be promoting foreign and potentially weak ties at the expense of local and potentially strong ties, this may suggest vulnerability in the adoption and use of Internet technologies. This could be an indication of an affliction outcome. However, the story is not all foreboding.

Mullin et al. (2000) suggested that there is an asymmetrical relationship in resources in the Chilean research sector. Research organizations in the capital city of Santiago, the core, enjoy a greater advantage in resources when compared to organizations farther from the capital city (the semi periphery and periphery). Even though this tends to reflect historical development literature on urban bias (Bradshaw, 1987), the data show that the core is not necessarily the most opportune place. In the Internet era, perhaps such a geographic distinction is challenged. Further, technology adoption and network research suggest that women in the developing world are at a disadvantage (Rogers, 1995; Escobar, 1995; Ekdahl and Trojer, 2002; Ynalvez et al., 2005). Yet the data here indicate that no major disparity exists by gender. Women are somewhat at a disadvantage in Chilean science, yet not where it may count most. In terms of Internet intensity and diversity, access to project grants, and size and reach of professional networks, there are no differences across gender. This indicates a clear internal elixir outcome. No matter the locale, the Chilean scientist regardless of gender may access resource flows by means of digital connection. This observation echoes Castells' (2000) preeminence argument of connected global nodes. In the digital age, framing resource flows in terms of geographical disparities of First and Third worlds is not as relevant as distinguishing between connected and unconnected regions. In Chile, the digital networking of the national research sector during the dictatorship, when combined with the recent concentration of the global aqua-culture industry in the periphery, tends to support this "networked society" contention.

To see how region and sector affect the relationship between collaboration and productivity in the digital era, in the proceeding chapter the study considers how scientific activities and Internet practice are associated.

CHAPTER SIX: PRODUCTIVITY, COLLABORATION, AND INTERNET PRACTICE IN CHILEAN SCIENCE

In this chapter, the study considers the relationship between collaboration and productivity within the Chilean context. The study also investigates how Internet practice mediates these professional activities. This is accomplished by considering a cross sectional comparison of Chilean scholars, their collaborative behavior, productivity patterns, and Internet use. This present analysis is framed by recent project publications on the interaction of collaboration, productivity, and Internet practice in Africa and India, applying 2000-2002 data (Duque et al., 2005). In this publication, the study first considered the relationship between productivity and collaboration, and then the relationship between email use and problems reported in conducting research. The findings suggest an interesting variation across 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. In the African case, an affliction argument may be made with respect to adopting both institutional pressures to collaborate and new technologies like the Internet. In the Indian context, the local IT industry and a well developed domestic research sector may explain the elixir affect of the Internet. As found in the previous chapter, Chileans are digitally well connected, compared to past regions studied. Also, Chileans enjoy robust international networks, perhaps a result of close to 50 percent of PhDs having been acquired abroad. This outward orientation may emanate from, and be reinforced by, an institutional need to publish in high impact ISI journals, many of which are published in the North. Moreover, in the qualitative phase of the Chilean study, many of the scholars interviewed suggested that in order to start projects from which publications result, one must seek a collaborator abroad to access resources. This perception is somewhat contradicted in the previous chapters, since having more local contacts was significantly associated with enjoying more grant awards.

In many respects, Chile suggests a combination of past regions studied: well connected like the Indians, yet internationally integrated like the Africans. As suggested previously, this combination has resulted in a more equitable distribution of resources and opportunities within Chile, yet at the same time Chile displays a disjointed or endogenous research sector much like that found in Africa. To find whether Chile's outward network profile and advanced Internet infrastructure may lead to differing associations between professional activities, productivity, and technology use, the following sections describe (6.1) how this study measures collaboration and productivity; (6.2) how collaboration and productivity in Chile are associated, controlling for other factors; and (6.3) how Internet use is associated with reporting problems in collaboration, concluding (6.4) with a discussion.

6.1 Measuring Productivity and Collaboration

In contrast with studies of scientific productivity that use bibliometric techniques, this present investigation replicates the previous study based upon African and Indian data. 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 has emerged 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 (Duque et al., 2005; Garg and Padhi, 2000; 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 these 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. 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). 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 accounted 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. 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, the study employed natural logarithm transformations for the self-reported number of professional meetings attended and journal subscriptions in the regression analyses.

Moreover, since the author is 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). A final control variable 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.

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, the author 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 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.

6.2 Collaboration, Productivity, and Email Use - Analyses and Findings

The following analyses and finding section first (6.2.1) describes the key mean distributions of dependent, independent, and control variables. Then (6.2.2) 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. The study concludes with (6.2.2) a treatment of email use and problems in collaboration, employing means comparisons and multiple regression analyses.

6.2.1 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 higher by a factor of four, compared to that in the previous study in India and Africa. In the author's present study in Chile, the self-reported sum of articles in national and foreign journals is seven (Table 6.1, line 1). This is on par with the Indians and significantly more than the Africans 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, their mean productivity in foreign journals 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. As indicated in Table 5.1 from the previous chapter, Chileans report working closely with 8.5 collaborators within their parent organization. Intra-organizational

TABLE 6.1

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

Productivity	Mean	N
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
Collaboration Frequency and Location		
5. Any current collaboration	79.5%	337
6. Number of current collaborations (3 maximum)	2.1	337
7. Number of domestic collaborators over three main projects	2.40	337
8. Number of foreign collaborators over three main projects	1.0	337
9. Exclusively Chilean collaborators	45%	153
English Language Dependence and Proficiency		
10. Use English Websites (1=frequently, 2=occasionally, 3=rarely, 4= Not at all)	1.3	334
11. English Proficiency (1=Very comfortable speaking English, 5 = Do not speak English)	2.4	337
11a. Very comfortable	23%	
11b. Comfortable	31%	
11c. Uncomfortable	31%	
11d. Very uncomfortable	8.3%	
11e. Do not speak English	6.2%	
Professional Awards and Activities		
12. Projects directed	1.73	337
13. Individual Award	3	335
14. Award as part of a larger project	2	332
15. Journals subscribed to	1.96	336
16. Held office in professional association	52.5%	337
17. Professional meeting attended	8	337

collaboration is highest in the location often characterized as having the lowest level of development.

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). 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). It was suggested repeatedly during the qualitative phase of the Chilean study that foreign collaboration fuels local projects because domestic resources are low and bureaucratic obstacles are high. Taking the lead from the previous investigation, the author measured external, or inter-organizational, collaboration as (1) whether the scientist was involved in <u>any</u> collaboration over three main projects, and (2) the <u>degree</u> 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 5). 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 6). 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 7). 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 8). When deconstructing this 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 6.1 reflects that on the average, Chileans report more than occasionally utilizing English language websites (line 9). Chileans also report being only marginally comfortable with communicating in English (line 10); although over 50 percent report being comfortable or better when communicating in English (lines 10a and 10b).

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 13 and 14). In addition, Chilean scientists averaged 1.73 projects directed (line 12), subscribe on average to almost two journals (line 15), and over 50 percent report holding an office in a professional association (line 15). 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 16). This is half the number reported by the Indians and Africans. In the qualitative interviews, the Chileans consistently commented on the low emphasis placed upon attending conferences. The conferences represented an unmanageable expense, were limited in terms of networking, and some mentioned the high degree of in-politicking involved in many conferences.

6.2.2 The Relationship between Collaboration and Productivity

To what extent is collaboration associated with publication productivity in Chile? In this section, the study examines 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 6.2 below 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

TABLE 6.2

CORRELATIONS OF FIELD AND PUBLICATION LOCATION

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

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

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 6.3 reflects the results of regressing the logarithm of total productivity on collaboration with several important control variables including field. Column 1 provides 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 6.3 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

TABLE 6.3

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

	Full Sample[a]	Academic[a]	Research[a]
Contextual Factors			
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
Background & Education			
7. Gender (male)	-.055	-.033	-.126*
8. Age	.017	-.013	.065
9. PhD	.245***	.254***	.188**
10.Degree from developed country	-.023	.029	-.092
Professional Activities and Awards			
11. Professional meetings attended[a]	.265***	.246***	.313***
12. Number of journals subscribed to[a]	.111**	.069	.165**
13. Individual awards[a]	.225***	.144**	.316***
14. Project awards[a]	.137***	.175***	.065
Networks			
15. Size of domestic network	-.065	-.032	-.092
16. Size of international network	-.008	.029	-.057
Collaboration			
17 Total Collaborations (out of 3 main projects)	.156***	.160**	.104
18. Intra-organizational Collaboration[a]	-.026	-.046	.020
19. R^2	.443	.376	.591
20. N	326	203	122

*** p < .01, ** p <.05, * p < .1

a. Variable is expressed as a natural logarithmic transformation.

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 6.3, 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, the study distinguishes between three dependent variables of productivity, foreign, domestic, and web.[45] Table 6.4 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 6.4 as a whole, collaboration is significantly associated with publication productivity in all but two models. Publication in

[45] 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 6.5 columns 5 and 6 represent the estimated odds ratio for each independent variable.

TABLE 6.4

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

	Articles In Foreign Journals [a]		Articles In Domestic Journals [a]		Web Publishing[c]	
	Academic	Research	Academic	Research	Academic	Research
Contextual Factors						
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
Background & Education						
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
Professional Activities/Awards						
10. Professional meetings attended[a]	.240***	.205****	.115*	.210**	.756	.952
11. Number of journals subscribed to[a]	.021	.224***	.062	.019	1.563**	1.772*
12. Individual awards[a]	.197**	.267***	.038	.159*	1.324	1.483
13. Project awards[a]	.105*	.047	.152**	.157*	.679*	1.111
Language						
14. English proficiency [b]	-.084	-.091	.217***	-.216**	.877	.514**
Networks						
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
Collaboration						
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[a]	-.067	.057	-.009	-.028	1.502*	1.572
20. R^2	.448	.623	.321	.436	.241[d]	.456[d]
21. N	203	122	203	122	203	123

*** p < .01, ** p <.05, * p < .1
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^2.

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 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 publishing in 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. 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. This finding contradicts the previous chapter, where the periphery and semi-periphery enjoyed advantages in terms of networks and technology. 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).[46] 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

[46] The negative association of age affect on web publishing in Table 6.4 is reflected by an odds ratio that is less than 1.

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 (odd 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).

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 6.4. In addition, although the number of international contacts (distinguished from foreign collaborators) has no effect on foreign publications, the number of domestic contacts did; the result 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 contacts. These findings also supply a context for the results from the previous chapter. The inverse relationship between local and international contacts may be a response to this imperative to seek high impact ISI publications, many of which are found internationally. Collaboration per say 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 significance 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. This factor 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.

6.2.2 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 projects 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 particularly, communication using email. 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, the author 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 6.5 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)[47] than the full sample of Africans and Indians in the previous study, but report more problems with 'too much information' (m = 2.05). This is confirmed in the qualitative interviews and may be attributed to greater Internet access and higher bandwidth, compared to the previous regions studied. More access means more meaningless information is

TABLE 6.5

MEANS OF PROBLEMS IN RESEARCH BY SECTOR[a]

Problems[a]	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

*** $p < .01$, ** $p < .05$, * $p < .1$
Significant differences reflect a one-way Anova means comparison test.
a. 'Research problems' coded as: 1=a major problem, 2=minor problem, 3=no problem

[47] Problems were measures as 1 = major problem, 2 = minor problem, 3 = no problem. The higher means indicate less of a problem.

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 6.5, 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, the author 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. The author 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 6.6 provides the results of a one-way Anova multiple comparison tests 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.[48] 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 is a significant increase in intensity of reported problems as scientists report more collaborators. Those with 4 to 7 collaborators (column 3) report significantly more problems

TABLE 6.6

MEAN OF SELF-REPORTED RESEARCH PROBLEMS AND COLLABORATION

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

*** p < .01, ** p <.05, * p < .1
Significant differences reflect a one way Anova LSD post ad hoc means comparison test. Letters (a ,b, c,) after means indicate specific differences between groups.
1. ‘Research problems’ coded as: 1=a major problem, 2=minor problem, 3=no problem

[48] 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 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.

than those with 1 to 3 collaborators or no collaborators (columns 1 and 2, 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 reported significantly less intensely problems than those with 8 or more collaborators for 'dividing work' (line 5). Finally, those with 8 or more collaborators (column 4) reported significantly more intensely problems than all other categories for 'too much information.'

Columns 5 and 6 in Table 6.6 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, the author employs three independent Internet dimensions that distinguish Chileans scientists: email age, hours using email, and email use diversity.

Table 6.7 reflects the results of twelve multivariate regression models, two for each of the six research problems distinguished as variable in the Chilean data. The study tests these by using many of the control variables presented in Table 6.4: region, sector, field, gender, age, and English proficiency. Then the author adds 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. The author 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. The author also controls 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 6.7, 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

TABLE 6.7

REGRESSION OF PROBLEMS IN RESEARCH ON EMAIL PRACTICE, COLLABORATORS, CONTEXT, BACKGROUND, PROJECTS, AND LANGUAGE

	Coordinating Schedules[a]		Length of Time Getting Things Done[a]		Transmitting Information[a]		Resolving Conflict[a]		Dividing Work[a]		Too much Information[a]	
	1	2	3	4	5	6	7	8	9	10	11	12
Internet Factors												
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**
Collaboration												
3 Total collaborators[b]	-.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
Contextual Factors												
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*
Background												
11. Gender (male)		-.009		.051		-.032		.023				.074
12. Age		.142**		.165***		.015		.006		.068		.034
										.058		
Projects												
13. Projects directed		-.128**		-.101*		-.106*		-.008		-.046		-.089
Language												
14. English Proficiency		-.156***		-.013		-.091		-.096		.022		-.129**
15. R^2	.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

*** p < .01, ** p <.05, * p < .1
a. 'Research problems' coded as: 1=a major problem, 2=minor problem, 3=no problem; negative coefficients indicate greater problems.
b. Independent variable is expressed in a natural logarithmic transformation

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,[49] the negative coefficients indicate more intense reporting of problems associated with more reported collaborators. Having an exclusively Chilean collaborative network is significant 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. There, 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 the authors 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.

The final series of models are reported in columns two, four, six, eight, ten and twelve of Table 6.7. The difference between these six models and simpler counterparts was the inclusion of controls for sectoral, regional, and field context, background, project administration, and English proficiency. What emerged in 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

[49] That is, a code of '1' represents a 'major problem; '2' represents a 'minor problem''; '3' is used for 'not a problem'.

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.

6.3 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 – the elixir effect.

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. So while awards, prestige, and Internet practice may favor the semi-periphery and periphery as indicated in Chapter 5, the balance of publications, the currency of science, is still very much entrenched in the regional core. 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 carries a 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 in the author's 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. In the following dissertation conclusion, the author synthesizes the interwoven patterns of relationships between contextual and social characteristics, Internet practice, professional networks, collaboration and productivity, and research problems.

CONCLUSION

This dissertation was a qualitative and quantitative study of the relationship between scientific communication, collaboration, and productivity in Chilean science, focusing on the role of Internet adoption and use. Prior work has identified an inverse relationship between domestic and foreign professional contacts among developing world scientists (Campion and Shrum, 2003). This exemplifies one element of the exogenous science profile (Sagasti et al., 2003); domestic scientists who are globally connected have few local contacts, while those scientists who are locally connected have few global ones. This is in contrast to counterparts in the developed world who enjoy a balanced degree of integration. Furthermore, the "Collaboration Paradox" (Duque et al., 2005) suggests that in resource-poor contexts, the high costs of collaboration may be greater than benefits in terms of output. The Internet is promoted as a technology that will change these dependent relationships; but so far its positive impacts have yet to be realized, while in some cases Internet use may actually retard productivity. But much of this work results from studies done in sub-Saharan Africa.

In providing comparative data from a Latin American region, the present study offered results from (1) a video-ethnography that included interviews with 29 Chilean researchers, followed by (2) a comprehensive communication network survey of 337 researchers. This author framed the possible outcomes of Internet practice in Chile in terms of 'elixir', 'affliction,' and 'teething' arguments as concepts that loosely mirror modernization, dependency, and globalization perspectives on development respectively. Three research questions guided this investigation: First, what social forces shape Internet practice in Chilean science?; Second, what is the relationship between Internet practice and professional networks in Chilean science?; And third, what is the relationship between productivity and collaboration in Chilean science and what is the role of Internet practice in mediating these scientific practices? If Internet practice was found to be characterized by exclusively foreign networking and publication behavior, and with reports of more problems in research, this was an indication of 'affliction.' If Internet practice was found to be characterized by a balance of both foreign and domestic networks and publication, and a reduction of problems in research, then there was an indication of an 'elixir' affect. 'Teething' could be considered in the case that results were mixed. The following discussion synthesizes the findings and extrapolates broader conclusions. These will address issues in science, technology, and development policy, while providing direction for future research in this area.

The Internet is emerging within the Chilean context as a transformative technology that shapes scientific networks, collaboration, and productivity along gender, institutional, and internal geographic dimensions, but does not necessarily reduce reported problems in research. However, this may result from the leveling-off effect of Internet use over time. It should be noted that before the Internet, science activities in the developed world tended to be male and core region-oriented. Is the Internet a technology that simply transplants these core tendencies into the developing world –the affliction argument? Just 25 years ago, only 4 percent of the Chilean research profession was female, and two of the three major research universities and all the major national research institute headquarters were located in the capital city of Santiago. Now close to 30 percent of the research sector is made up of female scientists and there are over 60 universities across the country, many of which support their own regional research institutes. Chile has adopted neo-liberalism and democratic organization for the last 30 years. Indeed, the process of decentralization and equality in the Chilean research community pre-dates the Internet. The bivariate and regression analyses of the Chilean data in chapter 5 may support the positive results of these historical internal processes to a certain extent. Certainly, it demonstrates that the core in Chile today is not always the most advantageous place to be in terms of resource flows and networks. And in regard to those in the core who do publish more, collaboration symmetrically promotes domestic, foreign, and web publications across contextual and social characteristics. Moreover, Chilean female researchers in the digital age are on par with their male counterparts in terms of access to technologies, resources and networks, and opportunities for publishing nationally and internationally. It was even found that female scientists in research institutes publish at higher rates in foreign journals compared to their male counterparts, while across sector they share research grants from a larger project with greater frequency than men do. Thus I can conclude that within the Chilean scientific community, the Internet continues a democratizing trend that has been breaking down traditional barriers along regional and gender dimensions —the elixir outcome.

But although the Internet represents a catalyst for overcoming historical internal divides, it may at the same time be promoting an outward orientation in professional contacts at the expense of local ones. This is not necessarily predicted by network scholars to be a positive outcome in terms of transfers of complex knowledge. Further, this process may be mediated through historical structural relationships that shape the location of advanced training, and, more recently, the institutional imperative to publish in high impact ISI journals. These relationships are reinforced in the present day by Internet practices—arguably an affliction outcome. But adoption of northern institutional forms and technologies does not necessarily translate into exclusively foreign productivity. For example, collaboration was associated with more domestic publication and not foreign, suggesting an elixir affect of adopting the Northern institutional behavior of shared work.

Taken together, these competing processes and outcomes may result from Chile's advanced digital and global economic profile, as compared to that of other developing regions. This strongly suggests that at present, Chilean science is experiencing a teething relationship with regard to adopting Internet technologies. The Chilean knowledge sector is taking advantage of the Internet to grow more equitably within, while perhaps transforming into an internationally competitive community over time. Only longitudinal data can confirm this latter process, though.

With regard to global policy and future research, Chile proves an ideal case study for promoting the institutional knowledge norms of international collaboration and adoption and use of new ICTs. But this may be a result of its unique historical profile, recent political stability, and productive links to the economies of the First World. These conditions can not be guaranteed in all developing regions. Thus, this author cautions modernization's "one size fits all" strategy. To support the growth of knowledge in developing regions through the simple transfer of homogenized institutional behaviors and technologies may prove near sighted. Science, technology, and development studies should direct research in ways that clearly map the historical and cultural dynamics that create exogenous and endogenous scientific infrastructures. For example, future research could distinguish the effect of interventionist science models in Mexico, Venezuela, and Cuba and how these differ in terms of the professional behaviors, networks, technology adoption and use patterns, and productivity when compared to the neo-liberal case in Chile. Other studies could consider the colonial legacies of Spanish, Portuguese, British, and Dutch rule across Latin and Caribbean America and how the Internet is being adopted and used by knowledge workers located in these distinct cultural regions. Still other investigations could consider geographical, political, economic, technological and cultural distances from core nations to distinguish scientific behaviors and technology adoption and use patterns. Without considering developmental distinctions across contexts, the adoption of northern institutional behaviors and technologies could waste valuable development time and resources that might have been applied elsewhere.

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VITA

Dr. Richard B. Duque's research addresses classical theoretical debates on social change and modernity in the present day: knowledge production and the global digital divide. At the intersection of development, science and technology studies (STS), organizations, and social networks perspectives his present work investigates how new information and communication technologies (ICTs) are shaping the global stratification of knowledge production. His dissertation examines the impact of the Internet on professional communication patterns and practices within the Chilean scientific community. His prior work in Africa has identified a "collaboration paradox": in resource-poor regions, the high costs of increased collaboration may be greater than their benefits in terms of output, supporting recent work in STS that questions the value of collaboration. While the Internet has been promoted as a technology that will change this relationship, his recent findings comparing African and Asian communities contradict this notion. His current work is based on a process theory that suggests conditions peculiar to sub-Saharan regions may be dissimilar to those elsewhere.

He employs quantitative and qualitative methodologies in his research. For the past half decade he has been part of the World Science Project, an international study of scientific communities in Africa and Asia that he has extended to Latin America. It is based on a 1994 pilot survey of 293 scientists in Kerala (India), Kenya and Ghana that subsequently became a multi-wave study in 2000, 2005, and beyond, with particular emphasis on the globalization questions raised by international scientific networks and collaboration. He is intimately familiar with the survey instrument employed, having coded, cleaned, analyzed, and published results from it. Recent papers with international colleagues have been published in Journal of International Development, Social Studies of Science, Scientometrics, and in an edited volume for MIT Press. He has recently initiated the project in Costa Rica and plans to take it to Mexico in the near future.

His background in film and theatre has been useful in the development of video ethnography as a sociological methodology and supplemental tool for teaching and research presentations. Over the past three years he and his colleagues have screened their academic films alongside traditional presentations at both national and international conferences, including at two World Summits on the Information Society in Geneva and Tunis. They have also recently published on the use of digital video in our connectivity study in Africa and Latin America in the Journal of Research Practice and the SAGE Encyclopedia of Qualitative Research in which they identify a variety of dimensions to digital video methods including the "normalization of surveillance," the reflexive "fluid wall," and the ethics of digital documentation. Unlike other ethnographic data collection methods, digital video has downstream applications that could magnify the vulnerability experienced by at risk groups. A publication with colleagues, based upon an ongoing video-ethnography on the socio-technical aftermath of hurricane Katrina, is forthcoming in Technology in Society. In addition, qualitative analysis and findings from his video-ethnography in Chile are published in an edited volume by Springer Books.