2009

Women and science in development: a longitudinal analysis of gender, networks, and information technology in Ghana, Kenya, and India

Beverly Paige Miller
Louisiana State University and Agricultural and Mechanical College

WOMEN AND SCIENCE IN DEVELOPMENT: A LONGITUDINAL ANALYSIS OF GENDER, NETWORKS, AND INFORMATION TECHNOLOGY IN GHANA, KENYA, AND INDIA

A Dissertation

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

in

The Department of Sociology

by
Beverly Paige Miller
B.S., Black Hills State University, 2003
M.S., Louisiana State University, 2005
August 2009

ACKNOWLEDGEMENTS

First, I would like to thank Dr. Wesley Shrum. Words cannot express the importance of his contribution to who I am as a sociologist. As a mentor and a friend, he has taught me a new way of viewing the world, one that goes beyond anything I could have learned in the classroom.

I would also like to express my gratitude to the faculty and staff at Louisiana State University for their support, encouragement, and guidance throughout the sometimes difficult process of graduate school. In particular, I would like to thank Dr. Susan Dumais, Dr. Rick Duque, Dr. Jeanne Hurlbert, Dr. Mark Schafer, and Dr. Marcus Ynalvez for their insights throughout my six years at LSU.

Thank you to Tonya Duthu and Jamila Beasley. Without these two women, life in the Sociology Department would come to a stop. I would also like to thank the graduate students within the Sociology Department who made life much more bearable and fun than it would otherwise have been. In particular, I would like to thank: Meredith Anderson, a better traveling partner could not be asked for; Tim Brown, for patiently putting up with me as an office mate; and Monique Norris whose friendship has meant a great deal to me. Without her, I may not have made it through graduate school.

Last, but never least, I would like to thank my family and friends who have stood by me through this process. In particular, I must thank John Hansen. His support, sense of humor, and love are my backbone. He is my best friend and my rock.

TABLE OF CONTENTS

ABSTRACT

This dissertation examines the gendered nature of the scientific career for researchers in universities and national research institutes in Ghana, Kenya, and Kerala India. Employing panel data, I analyze three issues related to the diffusion of ICTs in the scientific communities of less developed areas: 1) access; 2) interaction; 3) and involvement. More specifically, I examine the way in which human capital, family structure, travel experiences, contextual factors, and technological antecedents interact with gender to influence access to and use of personal computers, email, and the Web. From there, I incorporate technological behavioral changes to predict interaction within professional networks. In the last step, I incorporate professional network measures to examine the gendered nature of research outcomes in the form of scientific productivity.

The results suggest that over time ICTs have rapidly diffused within the three locations. At the same time, women continue to report less long-term access to email and the web. Furthermore, men and women are distinctly different in terms of intensity and extent of email and web use with women emerging as less technologically oriented. In spite of the differences on these measures, men are not earlier adopters of the technologies than women. It does not appear, however, that there is a consistent relationship between greater email use and integration within professional networks. Gender, on the other hand, emerges as one of the most consistent predictors of network outcomes, particularly in terms of absolute network size, geographic and gender diversity, and the proportion of male contacts reported.

Finally, men and women are equally productive in domestic venues, but women are less productive in foreign venues. Furthermore, network structure is not as strongly related to productivity as are changes in technological use behavior. Respondents using email for a wider

variety of reasons over time produce more in foreign and domestic venues, but intensity of email use is actually negatively related to productivity, suggesting that it is not technology use in general that matters when predicting outcomes, but the *type* of technology use. Network structure on the other hand, is only a significant predictor of domestic productivity.

CHAPTER 1: INTRODUCTION

This study examines the issues related to globalization and Internet diffusion in the context of the research system in three less developed countries: Ghana, Kenya, and the southwestern, Indian state of Kerala. I examine the interaction between time, place, and gender in order to determine the relationship between Internet access and use and the career outcomes of researchers. Specifically, I address three questions: 1) what gender differences emerge in access to and use of technological resources over time; 2) how do these gender differences in access to and use of technologies relate to the structure and composition of professional networks; and 3) how do such changes relate to career outcomes in terms of professional productivity in scientific journals.

In its 2007-2008 report examining the relationship between science, technology, and development, the United Nations Conference on Trade and Development (UNCTD) made the case that

> "in the context of a global knowledge economy fuelled by the fast pace of technological innovation, it is important for developing countries to lay good foundations for building their capacity to acquire and create knowledge and technology in order to take advantage of the opportunities offered by globalization and, at the same time, to address emerging global challenges" (xxiii).

And in 2004 the World Bank's Gender and Development Group in coordination with The Global Information and Communication Technologies Department issued a report asserting that, even more than other groups in less developed areas, women stand to benefit from access to and use of information and communication technology (ICT). Detailing what it would mean for women to fully participate in the global knowledge society, the report goes on to say "information and communication technology offers enormous potential for alleviating poverty and promoting sustainable, gender-equitable development." In order for this to occur, the report continues, the

"gender disparities in access to and use of…technology" must be identified and eliminated and technologies must be adapted to "women's needs by taking advantage of their special knowledge and strong informal networks and support systems" (1).

The stance adopted by the World Bank and the United Nations demonstrates the pivotal role that technology, knowledge and science play in the development discourse. These are only two of a multitude of accounts from development agencies, popular media, and academics touting the importance of ICTs for development.[1] According to many of these arguments, the ever expanding and relatively cheap cost of ICTs has ushered in a new global era marked by increased interconnectedness not only within and between wealthy nations but more importantly, between developed and less developed areas. In this relatively new globalized world, people and capital are traveling the globe at rates never before imagined; space and time are compressing resulting in easier access to information and easier engagement in communication without the constraints of co-presence. ICTs—particularly the Internet—are viewed as being intricately related to, if not the cause of, these dramatic changes.

Although the focus in much of the literature tends to be on the relationship between ICTs and economic growth, the processes of globalization and technology diffusion also hold significant implications for the structure of domestic *social* arrangements, two of which are of primary interest for this dissertation. First, the widespread diffusion of the Internet is predicted

[1] In April of 2002, for instance, the World Bank issued a report outlining its position on the introduction, dissemination, and implementation of communication and information technologies (ICTs) in developing areas of the world. According to the report, access to and use of technology possesses the potential to alleviate poverty and provide "opportunity, security, and empowerment for poor people" (2002: vii). The report goes on to briefly assert that the utilization of ICTs can bridge the digital divide not only across countries but also between men and women by "protect[ing] the people and promot[ing] social justice and equity" (64). More recently, on March 14th of 2006, the United Nations implemented what they term a Digital Solidarity Fund designed to finance projects that address "the uneven distribution and use of new information and communication technologies [to] enable excluded people and countries to enter the new era of the information society." Although, it is not specified who these excluded people are, one can safely assume that women are included in this category of individuals.

to hold significant implications for the nature and practice of knowledge production. Synchronous and asynchronous communication and access to a wide array of information through the World Wide Web and online academic journals has made the processes of collaboration, professional networking, and publishing easier particularly for researchers employed in highly functioning scientific systems—such as those in the United States, Canada, and Western Europe.

More importantly for the purposes of this study are the implications these same features hold for the *global* structure of science. Due to the creation of transnational communication networks along which scientific information can travel, researchers in developed and less developed countries may be able to engage in more intense formal and informal interactions. By making it easier for scientists in less resource rich institutions to access innovative ideas, cutting edge research and sources of funding, the Internet has been cast as the technology that could lead to researchers in less developed areas being more productive and more visible outside of their local scientific communities.

Related to this, the second interest of this dissertation is in examining the implications of ICTs for gender inequity within scientific institutions. While the emphasis on the role of science and technology in development is nothing new, the *gender* dimension has taken on new meaning with the production and diffusion of ICTs. Perceived as being more democratic and beneficial to the entire economy than past technologies, it is argued that ICTs will provide the opportunity for women and other marginalized groups to empower themselves and fully participate in the global marketplace. Due to historical and cultural environments marked by varying degrees of economic and domestic gender segregation, patrifocal family structures, and political and religious ideological support for sex stratification, the ability to use a technology from within the

home or personal office could be revolutionary for the gendered nature of scientific work in less developed areas.

These arguments, however, are not uncontested. The discourse coming out of the World Bank and the United Nations conceive of the development process as one of achieving modernity through technological diffusion. Conceptually speaking, the development community tends to view the relationship between technology and social change in a deterministic manner with technology acting as the catalyst for creating structural change. This is a very specific view of the relationship between new technologies and economic and cultural change, one that does not account for the social embeddedness of technology; the way in which technology is shaped by and reflects social relations of global, national, institutional, and inter-personal inequality. Far from creating a more egalitarian situation between developed and less developed areas and between men and women, the Internet may instead reinforce existing power dynamics both within and between countries (Schech 2002).

It is possible that the diffusion of ICTs to less developed areas will simply further dependencies that closely model the present global power structure. Because of Northern hegemony in trade, research and development expenditures, and in the production of ICT, the Internet will be no more appropriate for bridging the scientific divide than any other technology because it is not created with the reality of less developed countries (LDCs) at the core of the production process. For most people in LDCs, the initial cost of accessing these technologies are beyond their means and even for those in scientific institutions, who may have more access than the average person, use of the Internet may merely reify the central position of Western researchers. Scientists at the core will continue to be the central nodes in global scientific networks, more productive and more visible in scientific indexes and databases. Women in

LDCs, as a group that already occupies a position of less power than men, will fall further and further behind as the digital divide widens into a chasm.

There are, however, a number of problems with each of these arguments. First, there is little empirical data—beyond macro measures of Internet connectivity, cell phone subscriptions, and economic development—assessing women's access to and use of ICT in general and even fewer in the context of developing world science. Furthermore, while access is certainly a prerequisite to use, measuring access by no means provides an indication of actual technology practice or consequences of access and use. Second, the data that do exist are almost exclusively cross-sectional and as a consequence are unable to examine dynamic processes, which is particularly problematic given that the Internet is still very much in the process of spreading. And finally, these arguments are grounded in traditional development perspectives with the discourse surrounding ICT diffusion and processes related to globalization framed along a continuum of 'promises' on one end and 'threats' on the other (Schech 2002).[2]

In this dissertation, I argue that ICTs *are* distinct from past technologies for development, primarily because of the more democratic and horizontal nature of information in the knowledge society. Modern societies are built on access to information and the ability to produce, manage, and control knowledge. As a medium with the potential to disseminate information beyond the core producers of said information, access to and use of the Internet presents itself as a necessity. Beyond the ability to create, access, and disseminate new information, the Internet also presents

[2] It should be mentioned that there are differences, especially between the approach reflected in the statements at the beginning of this chapter and more traditional development perspectives. The primary distinction lies in the less state centered focus of knowledge and technology diffusion, with ICT, particularly the Internet, viewed as making knowledge more directly accessible to the people without the government acting as an intermediary (Schech 2002). However, the understanding of the role knowledge and technology plays in development is very much in line with the classic modernization approach adopted by policy makers immediately following the meeting at Bretton Woods following the end of World War II.

itself as a transformative technology. By easing the constraints of time and place on the ability of researchers to interact, communication technologies may be used to create new professional and organizational links and to strengthen existing ties. Without the criterion of co-presence inhibiting interaction, the way knowledge is produced and used could be dramatically altered through the creation of a truly global scientific network of researchers.

The way this actually plays out, however, is dependent on more than simply infrastructural capability and dissemination of the physical hardware required to access the Net. Instead, one most also account for the cultural context in which technologies and researchers are embedded (the macro level), the behavioral and organizational practices (the interactional level) in which researchers work and live, and the status of the researcher him/herself (the individual level), including but not limited to his/her career priorities and orientations.

Given the complex relationship between ICTs and the gendered nature of science, a more nuanced perspective than the ones presented above is needed. I assert that the technologically deterministic relationship between the Internet and social change needs to be replaced by an understanding of development and technological diffusion as a reagentive process (Shrum 2005). Reagency, a concept highlighting the importance of time, place, and identity in the development process, (Shrum 2005), argues that development be understood as a process of interaction between development agents and those comprising the focus of development aid.

It is important to note that actions and outcomes are always in relation to something else. Actions occur in social relational contexts in which people interact with one another and determine how to act themselves based on the nature of the interaction (Ridgeway and Correll, 2004). Whether that context is a face-to-face interaction or a communication that occurs online, people define their actions based on the place, the time, their own identities, the identities of

those they are interacting with, and according to the cultural scripts informing behaviors, values, and beliefs. Such an approach, then, is particularly useful when considering gender inequality. Gender stratification is a process embedded within interactions (Ridgeway 1997). Gender is an important variable in determining who has access to technologies, how those who have access actually use technologies and how technologies are designed. Given that action is embedded within place and time and is influenced by ones identity in relationship to others, the relationship between ICT and the gendered structure of science is far from deterministic. To the contrary, male and female researchers act based on a complex system in which agents within a society do indeed shape and use technology for often unexpected purposes but at the same time new technologies do have real consequences for social change.

I begin this discussion by detailing the theoretical framework I use to approach the issue of science, technology, development, and gender inequity. This dissertation merges literature from the sociology of development and globalization, the sociological study of science and technology, the sociological study of gender stratification, and studies on social network analysis. Using these frameworks, I critique the dominant discourses surrounding the role of science and technology in the development process more generally. I also critique women's relationship to technology and science more specifically.

First, I discuss the issues surrounding globalization and its relevance for a discussion of developing world science by focusing on three trends outlining the consequences of globalization for social life. Rather then view globalization as leading to dramatic social, cultural, and political changes, I argue globalization is best understood from a transformationalist perspective. Following this discussion I move to an examination of the major development perspectives and their understanding of the role of science and technology in the development process.

Historically, three perspectives have dominated the development discourse: the modernization perspective, dependency/world systems perspective, and the neo-institutional perspective. More recently, these discussions have centered on issues related to technology diffusion and the global digital divide. Each of these perspectives provides an historical and contemporary context in which to embed this discussion, but none of them are able to account for the reality of what we call development.

However, it is not development generally speaking that is the concern of this dissertation. Rather it is the practice of science within this context that is the concern. Following the discussions of globalization and development, I move to a sociological examination of the nature of science and technology. This dissertation starts with the premise that science and technology are socially embedded. They are integrated into social structure, not separate from it. Because the practice of science (the accepted and contested ideas and methodologies) and the creation, diffusion, and use of technology are socially embedded, structural relationships of inequality, including gender inequity, may be reflected in all the stages of scientific and technological production. Conversely, science and technology are also embedded within the flow of time and place, and they are intimately linked with the identity of the actors involved in the practice of science and the development of technology. The nature of inequality, the nature of women's interaction with technology, and the nature of stratification within scientific institutions are, as a consequence, not static but fluid.

In order to more fully detail what the consequences of new ICTs may be for women in the research institutions of less developed countries, I next examine historical and contemporary discussions related to women's relationship to science and technology more generally and then within less developed areas. I pay specific attention to two shifts within the discussion of

women, science, technology, and development: first, I document the shift from seeing women as unimportant to development, to seeing women as untapped resources within economic and cultural change. The development community has begun to pay special attention to the role women play within the economy and the home. Generally speaking, then, women have taken a central position within the development discourse. Specifically related to science and technology, I note the move away from viewing such practices as masculine endeavors, towards an examination of the socially constructed nature of gender roles. If gender is, at least to a degree, socially constructed, than the identities of men and women, their statuses and accepted behaviors, are critical to understanding their positions within science and their use of technology.

Given the emphasis placed on the transformationalist perspective, given the weaknesses inherent within many of the historical and contemporary discussions of development, and given the socially constructed nature of science, technology, and gender, I end chapter two by suggesting a new approach to these issues, one that accounts for the social structural constraints placed on people through their ties with others, but at the same time accounts for the nature of place and identity in influencing action and interaction. Rather than view development as a dichotomy—peripheral/core, domination/subjugation—a social network approach analyses ties and the exchange of resources along relationship lines. Reagency, on the other hand, provides a theoretical account of why the Internet represents a different development project, at the same time that it accounts for the *lack* of development.

Following the theoretical outline of the dissertation, in the next section, I provide a more detailed description of the data used, highlighting the important cultural and historical characteristics of the three locations examined. In order to address the questions summarized at the beginning of this chapter, I utilize panel data collected across two periods: the first extending

from 2000-2002 and the second conducted over the summer of 2005. An extensive amount of literature is available on women in science in developed areas and the literature is expanding—though certainly still small—on women employed in the scientific system of less developed areas. However, never before in the literature on science in the developing world has a systematic, *longitudinal* study of women employed in peripheral scientific communities been conducted. While this literature is informative, to fully understand the career trajectory, the research career cannot be examined at a single point in time.

Because Internet diffusion in many parts of the world is still very much in progress, employing a longitudinal and panel design to answer questions related to the interaction of ICT and the research career provides a more accurate picture of what is occurring in the research systems of less developed areas. Furthermore, the changing nature of familial responsibilities over the life course, the cumulative quality of an individual's professional network, and the cumulative character of the research career in terms of productivity, demonstrate that the career must be examined as a process (Allison et. al. 1982; Cole 1979; Long and Fox 1995; Smith-Lovin and McPherson 1993; Xie and Shauman 2003).

The final component of chapter three discusses the measurement of the major dimensions examined in this dissertation. Specifically, I investigate changes on seven dimensions of women's personal and institutional lives that have been identified as important determinants of research productivity. In chapter four, I examine the first five dimensions concerned with the bivariate relationship between gender and 1) family structure; 2) possession of human capital in the form of educational experiences; 3) localism expressed through travel experiences outside of the immediate environment; 4) contextual factors related to country of origin and organizational

context; and 5) the precursors to technological behavior, what I term technological antecedents. These five dimensions are employed as control variables in the remaining multivariate analysis.

In chapters five and six, I examine the final two dimensions, which comprise the primary interest of this dissertation. They concern the gendered nature of 1) access to and use of technological resources: telephones (landlines), personal computers (PCs), email and the web; and 2) the structure and content of professional and organizational networks. Although there are a great many themes involved in the study of new ICTs, I focus on three important social issues identified by Katz and Rice (2002): in chapter five, I examine *access* to and *use* of technology; in chapter six, I examine social *interactions* through the creation of professional and organizational networks. Finally, in chapter seven, I examine *involvement* in the scientific career through the relatively standardized measure of such involvement: productivity. I conclude in chapter eight by summarizing the major findings of this dissertation and the implications for future studies on the topic of gendered science and technology use in less developed areas.

CHAPTER 2: THEORETICAL FRAMEWORK

Centered on economic growth for a broad segment of the population in those countries formerly under colonial rule, the development project, or the creation of a "domain of thought and action" (Escobar 1995:10), institutionalized a view of the world as divided into distinct geopolitical entities: First and Third; North and South; core and periphery; strong and weak; mature and immature (Isbister 2003; McMichael 2000). The differences between these two worlds, developed and less developed, was seen primarily as a "matter of degree that could be set right by the development project" (McMichael 2000: 24).

Corresponding with the manifest goal of sustained economic and social progress was the formation of a global organizational frame comprised principally of the United Nations, the World Bank, the International Monetary Fund (IMF), and the nation state (Meyer et. al. 1997: 163). The development project was the forerunner to what would become a world institutional and cultural order. Newly independent countries and their political leaders had very little choice but to adopt the goals of this order in order to gain political legitimacy (McMichael 2000). Instead of generating the promised growth, however, the development project created a narrow and fairly stable vision of and discourse about LDCs and their path to 'modernity' (Escobar 1995; Isbister 2003; Meyer et. al. 1997). Modernity was, unquestionably, the end goal and specific policies, organizational forms, and individual identities defined the path to it.

Thirty years past the inception of the development project not only had those countries defined as underdeveloped, developing, or third world not 'caught-up' with the developed countries in standards of living or national economic growth, but the gap between developed and developing areas on such measures was actually widening (McMichael 2000).[3] By the late

[3] There were of course exceptions to this general rule. A group of middle-income countries, often referred to as the Newly Industrializing Nations (NICs), showed moderately strong growth rates in their economies. However, as

seventies, early eighties countries in Africa, Asia, and Latin America were saddled with debt. Western experts and policy makers argued that in order to manage the accruing debt, government expenditures and protectionist trade policies in underdeveloped countries should be reduced or eliminated (McMichael 2000; Stiglitz 2002; Wallerstein 2005).

Development, as it was originally planned, had failed, and out of the unraveling development discourse, the globalization project emerged (McMichael 1996; 2000; Wallerstein 2005).[4] At its core, this marked not simply a shift in political and academic terminology but a move from a focus on nationally managed social and economic growth, to a focus that stressed the positioning of countries in the *global* economy. The goal of development is still pursued, but the dominant discourse and policy agenda of politicians and business elites is global integration not specifically national growth (McMichael 2000). Although the institutions involved in the development project—the IMF, the World Bank, the UN, and of course, the nation-state—survived the transition to the globalization project, with this move came a discernible transformation in their *roles*. There was a significant ideological shift in how these actors were expected to participate in the making of development.

It is difficult, if not impossible, to understand the interaction between the Internet, science, and gender without a full understanding of the historical and contemporary discourse surrounding these issues. It is often within the context of the globalization and development discourses that the consequences of ICT diffusion are discussed. This section examines issues related to development and globalization in more detail. First, I examine four perspectives—modernization, dependency, world systems, and neo-institutional—employed in the social

---

McMichael (2000) shows, those countries classified as NICs were not a random grouping of underdeveloped countries whose domestic development policies were implemented successfully but were rather strategically placed to benefit from geopolitical forces that were largely beyond their control.

sciences to explain the process of economic and cultural development or lack thereof. I focus especially on the pivotal role science and technology occupy in these views of economic and cultural progress. Following this, I turn to the topic of women in development. For many years ignored in policy and academic discussions of economic development or at the very least assumed to occupy a secondary role, women in LDCs currently occupy a central position in development debates.

Although useful in establishing the historical and political context in which development as an ideal emerged and spread, modernization, dependency, world systems and gender theories are deficient. They are unable to adequately account for economic, political and social processes that are not defined solely by the nation state and closed communities (Anderson 2002). New perspectives accounting for the nature of global as well as local processes and the interaction between the two must instead be employed. I do this in the next section in a discussion of globalization. Three competing views on what exactly globalization entails are presented in order to establish a definition that account for both economic as well as cultural and social dimensions of globalization. While understanding what is meant by 'globalization' is necessary for this discussion, a definition alone does not provide a means for understanding the consequences of ICT diffusion for the gendered nature of scientific work in LDCs. Instead, new theoretical understandings of science, technology, gender and development; understandings that account for the changing nature of place, identity, interaction and knowledge production must be employed (Anderson 2002; Shrum 2005).

[4] Global economic trends had certainly started before the seventies. However, it was in the 1970s that the World Bank redefined development as "successful participation in the world market" (McMichael 2000: 111).

The Shrinking of Time and Place

Since the early eighties, the concept of 'globalization' and its implications has received an enormous amount of attention. In spite of the popularity (or notoriety) of the term, there is currently very little consensus concerning the nature of the process. When did it begin? What causes it? What will be the consequences of globalization for local communities and cultures? And, finally, what *is* globalization? Globalization is a combination of increasing interconnectedness as well as a series of projects designed to shape the global economic, political, and social environment (Nederveen Pieterse 2004). Increasing interconnectedness, furthermore, is characterized by both empirical processes of economic and political integration and subjective experiences that reflect a pervasive sense that the world is transforming, becoming smaller, and more interconnected (Held et. al. 1999; Nederveen Pieterse 2004; Uimonen 2001).

To understand the consequences of globalization, McMichael (1996) argues that the concept should be problematized as a "set of institutional and ideological *relations* constructed by powerful social forces" (26 emphasis added). At the broadest level, globalization is dominated by the relationships between multilateral organizations—the International Monetary Fund (IMF), the World Bank, the World Trade Organization (WTO)—and the economic interests of transnational corporations and national governments (McMichael 1996; Stiglitz 2002). But globalization operates at a more local level as well, shaping and shaped by organizational environments and the identities of individual people. Because *individuals* living and working in distinct places experience globalization, the impact of these trends is not easily generalizable (Nederveen Pieterse 2004; Schott 1993; Uimonen 2001). As such, sweeping

conclusions about the consequences of globalization on the political realm, compared to the economic realm, compared to the practice of science are likely to be oversimplified.

Held et. al. (1999), distinguish between three different perspectives on globalization: the hyperglobalist thesis, the skeptical thesis, and the transformationalist thesis. Each of these perspectives approaches the controversies surrounding globalization from a different angle, with the hyperglobalists positioning themselves on one extreme of a globalization continuum in terms of impact and conceptualization, the skeptics on the other extreme, and the tranformationalists somewhere in between the two.[5] I begin by discussing the hyperglobalist thesis. This perspective encompasses a number of important theoretical approaches for understanding globalization, including neo-institutional theory and global system theory. Next, I discuss the skeptical thesis, and I end by examining the transformationalist argument, which focuses on the "spatio-temporal and organizational attributes of global interconnectedness" (Held et. al. 1999: 17).

The Hyperglobalist Thesis

As stated above, the hyperglobalist perspective can be viewed as located at one end of a globalization continuum. With some variation, adherents to this perspective see globalization as a strictly modern phenomenon of increasing economic liberalization leading to a degree of interconnectedness never before witnessed (Held et. al. 1999; Scholte 2000). While adherents to

[5] Scholte (2000), on the other hand, argues that there are five distinct conceptualizations of globalization: globalization as internationalization, as liberalization, as universalism, and as Westernization. Because these approaches do not actually distinguish anything unique in the present form of globalization, he outlines a fifth approach that conceives of globalization as deterritorialization or supraterritorality. This approach not only describes what globalization is and what it entails but it also sets the current form of globalization apart from processes and trends that have existed for centuries. Although Scholte's (2000) categories may be more detailed, Held et. al.'s (1999) groupings offer a more succinct means of summarizing the various issues relevant for the present discussion. In fact, Scholte's (2000) categories could be viewed as subcategories within the three proposed by Held et. al. (1999). As such, the following discussion will place Scholte's groups into the categories laid out by the latter group.

this perspective recognize that globalization has a number of consequences beyond the market, the driving force behind the trend of increasing interconnections is economic and technological.

On the one hand, globalization trends are economic in that Western societies have a need for an ever-expanding market, which has led to a breakdown of national trade barriers and policies resulting in more intense and extensive movements across national boundaries and the "international integration of markets for goods, services, and capital" (Oman 1993; Rodrik 2000: 1). On the other hand, globalization trends are technologically driven in the sense that modern technological advances aid the creation of the network society (Castells 2000; McMichael 1996; Uimonen 2001). As Wellman (2001) maintains, computers are enabling people to transcend place and create communities that are everywhere (in the sense that connections will be established between people all around the world) but at the same time nowhere (in the sense that cyberspace doesn't have a physical location).

Under this perspective, globalization is associated with the creation of a borderless world, one in which the nation-state has ceased to exist as a viable political and economic entity (Held et. al. 1999). Globalization, understood as a system without national borders and autonomous nation states, makes a discussion of the world in terms of the old bounded entities of core, periphery, and semi-periphery obsolete (Wallerstein 2005). These boundaries, and the nation state through which international transactions once flowed, have virtually disappeared and with it the old division of labor. In place of the traditional world hierarchy is an emerging global system composed of three elements: the global elite, transnational corporations (TNCs), and an ideology of consumerism (Sklair 2000). Within this system, the global elite, working through transnational corporations, are essentially the economic winners and everyone else largely exists on the margins of the singular global society.

While the global elite direct the political sphere and the TNCs the economic, the ideology of consumerism dominates the cultural sphere. The ideology of consumerism is used to draw the masses into the global system, largely to the benefit of the global elite. What the hyperglobalists essentially describe, then, is a path towards a single society, an economic (TNCs), political (global elite), and cultural ideology of consumerism "convergence or growing sameness" (Nederveen Pieterse 2004: 42). Variously understood as Westernization (Scholte 2000), universalization (Nederveen Pieterse 2004; Scholte 2000), and/or McDonaldization (Nederveen Pieterse 2004; Ritzer 1993), proponents of this perspective see globalization as influenced by, and as leading towards, a Western model of consumerism and bureaucratic efficiency applied to all domains of social organization.

Increasingly, institutions within a given society are structured in a similar pattern and are imbued with similar values, making the spread of objects and experiences universal (Scholte 2000). Whether viewed positively, as the creation of new identities in the first global culture or negatively, as the rise of a new form of cultural hegemony in which traditional ways of life and cultural diversity are destroyed, the primary argument is that cultures, economies, and policies will converge in a unilateral move from "center to periphery" (Uimonen 2001: 9).[6] While economic dynamics are given the most attention as the primary force behind this hyperglobalized world, the role of modern forms of technology, particularly the Internet, within this perspective is also apparent. The creation of a global society or global village is argued by some to be based on information. The widespread ability to communicate and access information through such technologies as the Internet, is aiding this process, creating what some argue is "the formation of

[6] While the underlying argument of this perspective is that the core/periphery dichotomy will cease to exist, the cultural homogenization discussed by these authors is one based on a worldwide culture of consumerism. As such, it can be argued that what they are really suggesting is that the new, singular culture will be one modeled after Western/core ideology.

a world society as a single interactive network" (Hart 2000: 59, quoted in Uimonen 2001). The Internet is the "realization of the hyperreal" which exists in unbounded space; it is the "virtualization of culture that supposedly demarcates the postmodern, information age" (Uimonen 2001: 7).

The Skeptical Thesis

Whereas the hyperglobalists see globalization as radically altering economic, political, and cultural arrangements, the skeptics view this argument as exaggerated at best and as little more than rhetoric and hype at worst (Held 1999; Hirst 1997). Proponents of this position argue that previous historical periods exhibited a greater degree of international connectedness than contemporary societies. Using trade statistics as proof, they argue that instead of globalization what is currently happening is an increase in "interactions between predominantly national economies" (Held et. al. 1999: 5; Scholte 2000). Globalization is a surface level phenomenon that, when examined in more detail, reveals a core that is essentially regionalization. Similar to the hyperglobalists, they conceive of globalization largely in economic terms. Economic and technological processes, in other words, drive the globalization project. But rather than leading to the emergence of a borderless world in which North/South distinctions no longer hold any meaning, they argue that globalization is leading to a greater degree of inequality between countries and people. The violence and civil unrest occurring in many regions of the world is a testament to these increasing inequalities (Held 1999; Nederveen Pieterse 2004; Huntington 1993).

For the skeptics, the cultural changes wrought by globalization are just the opposite of the increasingly homogenized world predicted by the hyperglobalists. Globalization, from this perspective, is resulting in and will continue to result in, inevitable conflict, or what Nederveen

Pieterse (2004) refers to as cultural differentialism. Exemplified in Huntington's (1993) clash of civilizations argument, it is asserted that following the end of the Cold War, global interactions have shifted from being predominately between Western superpowers to interactions between the West and the non-West and among non-Western nations (Held et. al. 1999; Huntington 1993; Nederveen Pieterse 2004). As a result, allegiances are changing, leading to increased fragmentation along civilization lines. In order to defend what is seen by non-Western civilizations as an onslaught against their cultural identity, largely associated with a West vs. non-West dichotomy, new battle lines are being drawn in the global era. The rise of radical Islam is the most obvious example of the cultural differentialism associated with the skeptic's postindustrial age. Rather than the emergence of a global society, then, nations and people are breaking apart into "civilizational spheres…at whose fault lines conflict, no longer subsumed under ideology, is increasingly likely" (Nederveen Pieterse 2004: 43).

The Transformationalist Thesis

The transformationalist thesis tends to take a more multi-faceted view of globalization, seeing it not only in terms of economic change, but in terms of wider social transformations as well (Held et. al. 1999; Scholte 2000). Rather than making sweeping claims about the nature and consequences of globalization, they argue that an examination of specific social domains i.e. the political, economic, and cultural, in specific contexts provides a more accurate analytical tool for understanding global changes and consequences. This perspective combines and rejects features of both the skeptical and the hyperglobalist theses.

Siding more alongside the skeptics, the transformationalists, argue that global trends are hardly distinctive to the present period. In fact, exchanges across national and regional boundaries have existed for centuries, making the globalization project as we know it today the

product of lengthy historical processes (Held et. al. 1999; Nederveen Pieterse 2004; Robertson 2000; Scholte 2000). Not to be confused with an argument of a linear evolution towards globality, the historical development of globalization has gone through a number of shifts, at various times creating a more or less global/interconnected world. With that said, the transformationalists do argue that contemporary changes in societies all over the world are occurring as a result of a 'sped up' globalization. While global economic and political interactions may not be entirely new, globalization as a "view of ordering the world is" (McMichael 1996: 31). In agreement with the hyperglobalists, then, the transformationalists argue that there is something distinctive about the present form of globalization (Robertson 2000). It is the driving force behind existing political, economic, and cultural transformations.

There are two dimensions that distinguish the present form of globalization from its antecedents: the first is a spatial and temporal dimension and the second is an organizational dimension. The transformationalist argument understands globalization as:

> "a process (or set of processes) which embodies a transformation in the spatial organization of social relations and transactions—assessed in terms of their extensity, intensity, velocity, and impact—generating transcontinental or interregional flows and networks of activity, interaction, and the exercise of power" (Held et. al. 1999: 16).

According to this position, then, the extent of global networks, the intensity of global interconnectedness, the speed of global flows, and the impact that it has had on different societies must all be taken into account when distinguishing globalization throughout time. This dimension provides an idea of the shape of globalization, but there is also a need to understand the organizational traits of global trends over time. These include infrastructures capable of maintaining or constraining global processes, the extent to which global processes have been reproduced across time and space through institutionalization, the structure and degree of stratification, and the types of relations between nations (Held et. al. 1999; Scholte 2000).

Using these two dimensions, Held et. al. (1999) examine globalization in four historical stages: premodern, early modern, modern and contemporary. While the contemporary form of globalization does not represent a radical break from the past, it takes a distinctive form due to a combination of social, political, economic, and technological factors. The spread of rationalism as view of the world; regulatory frameworks to reproduce global policies and trends; capitalist developments such as the need for expanding markets and the breakdown of economic protectionism; and finally, innovations in ICTs which have collapsed space and time, all combine to make contemporary globalization trends more intense and frequent than in the past (Scholte 2000). The Internet, then, is just one of many components that make the present form of globalization 'thicker' than in the past.

While the contemporary form of globalization may be more intense, the impact is not a one-directional flow from the social structure to hapless individuals (Held et. al. 1999). People react, participate, shape, and resist global trends to varying degrees to create mixed cultures (Nederveen Pieterse 2004). Also termed glocalization (Robertson 2000), or creolization (Uimonen 2001), this perspective argues that actors create hybrid cultural forms and identities. They are informed by global trends, but they also alter institutional forms for better or worse. The *effects* of globalization are not felt uniformly. They are mapped and experienced differently for someone living in Louisiana compared to someone living in Kerala, India, for men compared to women, and at different historical periods (Nederveen Pieterse 2004). Nor does the *process* of globalization occur uniformly. The process of globalization does not translate into the end of the nation state or the end of societies and the emergence of a society. Instead, cultural change occurs within continuity (Scholte 2000; Nederveen Pieterse 2004).

To summarize, both the skeptical and the hyperglobalist theses are incomplete. Although they may conceive of globalization as headed in two opposing directions: increasing convergence (the hyperglobalists) and increasing divergence (the skeptics), both perspectives conceive of globalization (or what we call globalization) as a deterministic process of economic change leading towards a specific point. These changes are all encompassing and fairly predictable. In the world described by the hyperglobalist, place and identity essentially cease to be important as all societies adopt a single set of values and norms. And in the second world, place and identity are sources of never ending conflict. Regional loyalties become the new tool of war (Nederveen Pieterse 2004). The third perspective on globalization, the transformationalist thesis, is a synthesis of these two arguments. According to this perspective, discussions of globalization centered on a predictable process leading to a fixed destination—a borderless world or regionalization—are inaccurate. Instead, the transformationalist situates the "local in the global and the global in the local" (Nederveen Pieterse 2004: 57). How does this idea of hybrid cultural forms and mixed identities apply to the introduction of the Internet into developing areas? More importantly, what implications do the social changes associated with globalization hold for the practice of science in developing areas?

Historical Technoscientific Dualism

In spite of the increased attention paid to Internet diffusion and globalization, not everyone is included in the global information and communication web. Both within and between countries, groups existing on the margins are largely passed over by the benefits of ICT diffusion mentioned in the World Bank report. Citizens within wealthy industrialized countries lacking the resources and education required to access the Internet do not benefit to the same extent as their wealthier, more educated compatriots. And large segments of the population of

those nations often referred to as the 'global south,' the 'Third World,' or 'less developed,' especially women, racial or ethnic minorities, and the poor, are also not benefiting.

From its inception, the science and technology have played a pivotal role in policy issues and academic debates concerning the economic future of less developed countries. Inherent within the earliest visions of development as outlined by the modernization theorists was the notion that those countries at the core of economic and political decision making would act as both a model and a financial assistant and a source of technological advice for those countries on the periphery of such decision making. A fundamental element of the institutionalization of the development ideology was the role science and technology were expected and are still expected to play in generating social change (Bucchi 2002; Drori et. al. 2003; Meyer et. al. 1997).

The mid-twentieth century marked a shift in science from Little to Big (Bucchi 2002; Drori et. al. 2003). This was an historical transition that had been occurring for centuries. However, after World War II, there was a noticeable change in the role of science and technology (Bucchi 2002). The tremendous advances in technological know how, the role of science in policy decision making, and the expansion of funding for research endeavors created a central position for science and technology in development discourse. Indeed, the "consequences of scientific discovery and technological innovation [were seen as] decisive influences on the fate of nations" (Bucchi 2002: 14). Without access to contemporary science and technology, the necessary infrastructure for the creation of cities, industry, and advanced agriculture would not be accessible. Modern education systems capable of creating a literate and well-informed population were necessary for the maintenance and improvement of these infrastructures. In other words, science and technology were integrated as required tools for an environment favorable to progress (Escobar 1995).

Indeed, according to much of the early literature regarding global research and development (R&D), the primary agenda for less developed areas should be to create an environment favorable to the expansion and development of new technologies. Although the gap between more and less developed countries in their production of technology and scientific knowledge was quite large, it was assumed that simply transferring the institutions and technological capabilities of more developed areas to less developed areas was all that was needed in order for growth to occur. Technological dualism, in other words, was identified as the problem and 'catching-up' the solution. From the inception of the development project, then, the expansion of science and technology in underdeveloped areas was viewed as essential to the formation of a modern society (Escobar 1995; Yearley 1988; Shahidullah 1991). They were both symbols of modernity and a means to achieve it (Uimonen 2001). In reality, however, the largely Western science and technologies have proven to be unsuitable for the needs of many developing areas.

Partly as a consequence of this, a number of challenges to the mainstream development discourses have emerged to account for this seeming paradox. These challenges question the assumption that science and technology are appropriate tools for development and whether development, at least as it was originally conceived, is even a desired goal to begin with (Escobar 1995). In the pages that follow, I attempt to locate the role that science plays in traditional and contemporary discourses on development. Although there are a number of theoretical perspectives that examine the nature of development, I discuss three approaches here: modernization theory, dependency/world system theory, and neo-institutional theory.

Modernization Theory

The initial conception of the development project as described above is essentially the approach taken by adherents to the modernization perspective. Indeed it was this perspective that dominated much of the development discussion from the 1950s to the 1960s, with little challenge from outside views—though outside perspectives certainly existed (Chirot and Hall 1982). Arising primarily from the functionalist and evolutionary ideas of social change, this approach, very simply, asserts that development and modernization are inevitable ends for all or most countries (Harrison 1988). The focus for modernization theorists, whether examining structural or social-psychological aspects of a country or region, is largely on the internal forces that enable or block change in the direction of economic progress (Harrison 1988; Inkeles and Smith 1974). With some variation, modernization theorists argued that aspects of traditional social structures and modern structures are incompatible. In order to experience growth of any kind, people, values and institutions must move from traditional (i.e. rural, agricultural societies) to modern (i.e. urban, industrialized societies). They could not be both (Levy 1972; Inkeles and Smith 1974). For most modernization theorists, the goal of development and its inevitability was not a contested issue. Although the speed and path development might take was debated, development itself never was.[7]

If modernization theorists are correct in their assumption that all societies will eventually transition from traditional to modern, h*ow and why does this transition occur?* As stated previously, for many modernization theorists this transition was inevitable. At some point, all countries would modernize. Rostow (1960), for instance, argued that at any point in time all countries can be placed in one of five categories denoting their economic and social position:

[7] Levy (1972) veers from this optimistic path by arguing that for those societies that have not yet modernized, the latecomers, it may in fact be too late.

traditional, transitional, take-off, drive to maturity, and finally a stage of high mass consumption. While some countries, the United States, for instance, were already well into stage five, others would require a certain amount of catching up. Again, it was not really a question of whether or not they would catch-up; it was more a question of providing the right stimulants for growth including technology, entrepreneurialism, and favorable political systems (Rostow 1960). The path to development, furthermore, did not necessarily have to proceed in the order of the five stages outlined by Rostow. To the contrary, with the developed countries having already traversed this path, developing areas could, in a sense, learn from their mistakes and skip a few of the steps. Others focused more specifically on the cultural dynamics within a given country (Inkeles and Smith 1974). Modernization from this perspective is a "process of change in ways of perceiving, expressing, and valuing" (Inkeles and Smith 1974: 16; Levy 1972). The move from traditional to modern society requires that people first make the transition from a traditional way of thinking and valuing to a modern one. Typified by openness to new experiences and a sense that one's destiny is controllable (to name a few), this change was thought to occur through exposure to a series of modernizing experiences in schools and factories. Modern thinking citizens are created and they are the prerequisite for modern nations. Again, this reinforces the idea that traditional and modern cannot coexist.

The variation between the structural approach (Rostow) and the social psychological approach (Inkeles and Smith) aside, both perspectives argued for the role of science and, more importantly, technology in the transition from traditional societies to modern. Science and modernization/development were essentially part and parcel of the same project. The very traits thought to characterize modern societies: a high degree of specialization, "universalism, centralization, rationality, and functional specificity, possessing bureaucratic organization…" are

embodied within science itself (Harrison 1988: 40). In this way, the ability of a country to produce and use scientific knowledge and technology, specifically Western, scientific knowledge and technology, is essentially what makes it modern (Bell 1994; Bucchi 2002; Escobar 1995; Hicks and Katz 1996; Shrum and Shenhav 1995; Stehr 2001; Uimonen 2001; Yearly 1988).

The importance of science's role in development can be found in Rostow's description of the social structure in traditional societies as "based on pre-Newtonian science and technology, and on pre-Newtonian attitudes towards the physical world" (1960: 100); in Levy's (1966) conception of development as the degree to which a society has developed its inanimate power and tools (Harrison 1988); and in the emphasis placed on formal schooling and industrialization by Inkeles and Smith (1974). In fact, other theorists following Rostow argued that a sixth stage of economic development, a post-industrial stage, should be added to the original five (Bell 1994). What distinguishes a sixth stage of development? It is the ability of a society to produce and consume information and knowledge (Bell 1994; Chirot and Hall 1982; Stehr 2001).

The modernization perspective has been critiqued on a number of levels. First, the perspective is biased towards a Western ideal of what it means to be modern. Everything local or traditional about a country, from this perspective is devalued. In fact, modernization theorists see the cultural distinctions between developed and less developed areas as being a hindrance for less developed areas. The fatalistic attitudes and kinship orientation found in less developed areas are holding them back, preventing their inevitable move forward. This emphasis on the determinism of internal traits and characteristics in the development process has also been criticized for its neglect of external factors that *actively* work to create underdevelopment. These critiques see underdevelopment as being directly linked to the capitalist economic system, which relies on regional specialization in specific exports and imports. And finally, modernization

theory has been critiqued for its view of science and technology as neutral forms of knowledge. It is to these theories that I now turn.

Dependency/ World Systems Theory

The primary distinction between modernization theories and dependency and world system theories is their conceptualization of the role played by external forces in the development of underdeveloped areas. According to the modernization theorists, development is a stage and nation-states—bounded and autonomous entities—will develop given improvement in scientific and technological sophistication and changes in the value orientations of its citizens. In contrast to the modernization theorists, as well as neoclassical economists, dependency theory (Frank 1979; Cardoso and Faletto 1979) and its North American counterpart the World System Theory (Chase-Dunn 1975; Chirot and Hall 1982; Wallerstein 1974), holds that the ahistorical and acontextual focus of Rostow (1960), Levy (1972), and Inkeles and Smith (1974) is deeply flawed. The primary focus given to internal factors to explain the lack of economic development, they argue, is both oversimplified and self-serving. Dependency theorists instead examine the historical ties between underdeveloped countries and more developed areas.

A basic tenet of dependency and world system theories is that development and underdevelopment are really part of the same system: the world capitalist system (Harrison 1988; Wallerstein 1974). The nation state, according to these theorists, is situated in a worldwide struggle for economic and military power. As with any struggle, there are winners and there are losers. In the competition they describe, the 'winners' are, of course, the more powerful nations—the core or metropole—and they benefit from the position of the 'losers,' the less powerful nations—the periphery or satellite. Through direct exploitation, structural manipulation and control of other nation's economic policy, the powerful nations sustain their

dominant position and ensure the subordinate position of the less powerful (Chase Dunn 1975). Essentially, they argue that dependency is forced on less developed areas in the form of foreign investment, foreign aid, and international trade, and this creates underdevelopment (Chase-Dunn 1975; Chirot and Hall 1982; Wallerstein 1974).

Frank (1979) used the phrase 'the development of underdevelopment' to illustrate this concept. He argues that internal productivity and capital accumulation are hindered or facilitated by factors external to any given country. For underdeveloped areas, assistance from foreign sources in the form of aid and technology contributes to their state of dependence by transferring the value from such aid from the periphery to the core where it originated (Chase-Dunn 1975; Frank 1979). This state of dependency and underdevelopment furthermore are inevitable. Underdeveloped countries are consistently behind industrialized areas in part because they are forced to produce the exports the developed areas need but are no longer profitable for them to produce. At the same time, they import the more profitable goods from these centers of production, thus there is an unequal exchange that traps the internal market of developing areas in a cycle of dependency (Frank 1975). In other words, for one country to be developed another has to be underdeveloped. The present form of dependency may be more indirect than say colonialism, operating through "private investment by transnational corporations…foreign aid programs and credit agencies…and through specialization in a marginal role in the international division of labor," but it is dependency just the same (Chase-Dunn 1975: 721).

Implicit in Frank's description of dependency is the idea that the world is divided into two types of societies: the exploiters and the exploited or what he refers to as the metropole and the satellite (Harrison 1988). Wallerstein (1974) adds a third layer to this division, arguing that three regions make-up the world system: the core, the periphery, and an intermediate category,

the semi periphery. In Wallerstein's conception, a peripheral country can move out of its position as exploited and move into a position in which it acts as sort of a buffer between the core and the periphery. In this semi-peripheral position, a country acts as both exploited and exploiter, exploited by the core for its resources and its access to the periphery, while at the same time exploiting the periphery. Even with the presence of this intermediate category, however, the basic idea is that the world system of core, semi-periphery, and periphery continues to exploit and enrich (Wallerstein 1974).

Although dependency theories and the world system theory are similar in a number of respects, they do differ. Frank (1975), for instance, limited the scope of his theory of dependency to Latin America, whereas Wallerstein (1974) extended his ideas to the world *system* (Harrison 1988). In part as a reaction to this systematized theory of dependency, many theorists began to return to a country and empirically (as opposed to primarily historical) based elucidation of social change (Harrison 1988). Similar to Frank (1975), Cardoso and Faletto (1979) examined dependency in the context of Latin America. Unlike Frank, however, they explicitly argued for the equal force of internal and external factors in shaping the dynamics of social change. The internal class formations and struggles of a country are both important to external exploitation by more powerful regions. There is in fact a dynamic interplay between the two that creates both consistencies as well as surprises in the development experiences of various areas.

Another approach, referred to as dependent development, argues that some countries experience both dependency and development (Bradshaw 1988; 1993; Firebaugh 1992). Most studies of dependency argue that foreign investment in a country is associated solely with harmful effects. Dependent development theorists, however, argue that some countries may rely

on foreign loans and foreign direct investment in order to develop the domestic economy and infrastructure, but they also show fairly strong economic growth. In this way, foreign investment may actually be beneficial for developing areas. Bradshaw (1988) and Bradshaw et. al. (1993), for instance, examined the case of Kenya and Korea respectively to demonstrate the way in which a strong state, foreign aid, and local business elites can create a state of dependent development.

Science plays in intimate role in creating economic dependency and 'backwardness' in developing areas by shaping science and technology after Western societies needs and environments. The knowledge created within scientific institutions, as I discuss in part three, is inherently biased towards the needs and infrastructures of those societies. As such, from this perspective the application of these technologies in developing areas will be both inappropriate and destructive. Far from being a neutral tool for development, science and technology have been used to exploit developing areas since the colonial era (Schofer 2004). Without scientific research the ability of the West to expand into and withdraw the raw materials and other resources from the former colonies would have been limited (Schofer 2004). Science and technology are just another form of foreign aid making those countries on the periphery dependent on Western science and technology in order to increase the profits for those countries where the technologies originated.

To reiterate, the primary distinction between the dependency and world system perspectives and the modernization perspectives discussed above, is that the former examine the place of developing countries in the world capitalist system. The historical ties between developed and developing areas determine a countries current level of social and economic progress, not internal or cultural traits. Whereas the modernization perspective has been

criticized for its neglect of external factors, dependency and world system theory have been criticized for their neglect of internal factors. And while the focus on external factors in the creation of underdevelopment was needed, the generalized nature of Wallerstein's world system theory is one of the primary criticisms leveled against it. By focusing on a world system of capitalist development (and underdevelopment), Wallerstein neglects the variability between and within countries. From this perspective, culture is of secondary importance "merely mirroring economic and political dependence" (Harrison 1988: 145). The people inhabiting the core, periphery, and semi-periphery are essentially treated as agency less, passively accepting their roles in the world class system.

Neo-institutional Theory

Regardless of whether or not development is inevitable or whether science and technology are necessary tools for such development, most countries are committed to both (Drori et. al. 2003; McMichael 2000; Schofer 2004; Shrum and Shenhav 1995). More than simply a worldwide commitment to development and the expansion of scientific research, there is a surprising degree of similarity in the organizational forms and policies found in developed and developing areas. The final theory on social change to be discussed here, neo-institutionalism, examines the nature of this similarity. Neo-institutionalists examine why development has taken the form that it has from the nation-state, to a specific profession, down to individual value-orientations. Why is it that education, modeled after Western institutions, is almost universally valued? Why is it that most countries value the rights of the individual or the end of discrimination based on ethnicity or gender (in ideology and policy at least)? Why do most countries value the idea of economic development in the form that it has taken?

The answer, according to a neo-institutionalism, is that the nation state, and the organizations and associations that comprise the nation state, have "adopted externally defined identities" from the world institutional and cultural order (Meyer et. al. 1997: 154). To be recognized as a rational actor to other nation-states following the widespread independence movements in the post war period, most countries adopted a recognizable identity centered on certain goals and purposes as a nation. The patterns found within nation states, furthermore, are made possible by the standardized scripts and roles that are made available to individual actors within the various organizations and associations comprising the nation state. The similarities in organizational forms, or institutional isomorphism, transpire through three mechanisms (DiMaggio and Powell 1983). The first mechanism occurs through coercive tendencies from other states or organizations. The second, mimetic isomorphism, occurs in situations in which the goals of a nation or the means to achieve those goals are uncertain. In situations like this states or organizations will adopt a similar structure to avoid this uncertainty and create a sense of stability. And finally, the third mechanism by which increasing similarity occurs is through the desire of organizations and states to achieve legitimacy in the eyes of other organizations and states (DiMaggio and Powell 1983; Shrum and Shenhav 1995). Developing countries, for instance, may adopt certain policies or create an administrative branch in order to appear legitimate to other states, even if they do not actually *do* anything.

While the world institutional and cultural order (Meyer et. al. 1997) may construct familiar forms of the nation-state, organizations and associations, and individual human identities, this often is not functional or rational when applied to the local level. Consequently, many states may implement certain policies but never actually reinforce them. There is, in other words, a decoupling between ideology and action because "nation-states are modeled on an

external culture that cannot simply be imported wholesale as a fully functioning system" (Meyer et. al. 1997: 154; Uimonen 2001). This inefficiency manifests itself in other ways as well. Political leaders and development planners, will institute projects, such as the building of a dam, that are either damaging to local communities or do not directly benefit them. However, by undertaking the building of a dam the state is presenting the image of a country that is open to growth and that values modern infrastructures.

Science and technology play a central role in the world society described by neo-institutionalists (Gaillard et. al. 1997; Meyer et. al. 1997). Science is widely "accepted as legitimate and valuable," indeed as an *essential* part of and tool for, social progress and economic growth (Drori et. al. 2003: 3). It is part of a wider global cultural framework that is said to value rationalism as a way of understanding the world, democracy as a way of organizing societies, and continual progress in the ability to master the natural environment for the benefit of human kind. Uimonen (2001) refers to this as the modernization myth. Modern understandings of development can be understood as centering on a myth that societies are becoming information societies. The institutionalization of science refers to the fact that in order to be legitimated and recognized as a society in pursuit of modernity, one needs to adopt certain cultural and social forms. Such cultural forms include science and technology. Science and technology both constitute a modern identity, and at the same time, reproduce it.

While this theory helps explain the ritualized nature of organizational activity even in the face of apparent inefficiencies or even destructiveness, it does not provide an account for the changing nature of time, place, and identity associated with such technologies as the Internet and the associated social changes of globalization. Although it recognizes the importance of culture by arguing that a world cultural order is naturally going to create a disconnect between the state's

goals and the local context, it fails to fully develop this idea. Further, while it recognizes the role that the adoption of technology and science play in the 'myth of modernization,' it does not examine this in the social contexts in which technology diffusion occurs. The three theories of social change just described are not able to effectively account for globalization processes largely because their focus is on specific, place bound actors internal or external to the nation-state. More contemporary discussion of technology and development tend to center on the notion of the presence of a global digital divide, a topic to which I now turn.

The Global Digital Divide

One major discussion of the role of technology in development centers on the global digital divide. Stated simply, the digital divide "concerns the starkly differential extent to which various forms of information technology (IT) (such as the Internet, computers, and mobile phones) benefit rich countries rather than poor countries in terms of production as well as use" (James 2007: 284). The digital divide is not necessarily a dramatic departure from the technology divide that has existed for years between poor and rich countries. However, the digital divide is distinct from the technological divide in some respects. For instance, owning a TV or radio is quite different from owning a personal computer with access to the Internet that requires the acquisition of a certain skill set in order to fully use the technology (James 2007).

There currently exist dramatic differences in the rate of ICT adoption between developed and less developed areas. The question that needs to be asked, then, is does the digital divide matter? Is access to and use of ICT important to the well being of those who use the technology or conversely is lack of access and use detrimental to those who cannot use the technology? In answer to this question, a debate has emerged between those who see the Internet as unproblematic—variously referred to as the elixir or utopian argument—and those that see the

Internet as the creation of a new divide between rich and poor countries—the affliction or dystopian argument (Davidson et. al. 2002; De Roy 1997; Katz and Rice 2004; Patterson and Wilson 2000; Schech 2002; Uimonen 2001; UNCTD 2007-2008). Those supporting the Internet as elixir argument suggest that by providing developing areas with the technology and infrastructure they will be able to "reap the fruits" of the information society and leap frog through the development process, skipping the intermediate 'stages' of economic growth.

The affliction argument is not so optimistic. Adherents to this perspective argue that the social inequality both between countries and within will merely be applied to the domain of Internet access and use. In much the same way as previous development projects, processes of Internet diffusion will merely reflect the vested interests of powerful groups and organizations in the global economy (McElhinney 2005). When considered in the context of the globalization literature, adherents argue that proof can be found in the policies related to free trade promoted by the World Trade Organization (WTO). The Internet will thus have little impact on the research careers of scientists in developing areas.

I argue here that the digital divide argument itself is flawed in a number of respects (Warschauer 2003).[8] Chief among the various flaws contained within what some refer to as the first digital divide argument is the notion that there are simply two groups: the technological haves and have-nots. A more accurate depiction of the situation is of a technology divide based on a continuum ranging from those with no access and low skill, to those who are the most frequent, intense, and skilled users (Warschauer 2003). Because of the variability between these

[8] Warschauer (2003), for example, argues that the notion of a binary digital divide is both overly simplistic and inaccurate. Among other weaknesses, the digital divide's argument implies that the technological have nots face a number of challenges as a result of their lack of access. However, the argument is unable to accurately determine cause and effect. In other words, simply providing low-income minority groups with access to the Internet is not sufficient to improve their life chances. While it may be true that lack of access to the Internet is detrimental, the "reverse is equally true; those who are already marginalized will have fewer opportunities to access and use computers and the Internet" (7).

two extremes, a true assessment of the 'digital divide' must examine not only who has access to the Internet and who does not but also how those who have access are *using* the Internet in terms of both frequency and activity (DiMaggio et. al. 2001). Instead of focusing on the first digital divide, the concentration now needs to be extended to the second digital divide (Attewell 2001). With these findings in mind, I assert that the definition of the digital divide itself should be redefined as a matter of skill. In other words, access may be prerequisite to use, but in more developed areas and in the research systems of less developed areas, access has become much more widespread, suggesting that examining access in and of itself no longer adequately captures the workings of the global digital divide, a topic I return to in chapter five.

But first, to more fully understand the failings of science and technology to bring about the rapid industrialization expected by many of the early adherents to the modernization perspective and the current policy makers within the WTO, I first need to examine more completely the sociological perspective on science and technology. Knowledge and information in the contemporary world are often the basis of prestige and power, making science an ideal setting for examining issues related to globalization, technology, and gender.

The Nature of Science and Technology

Science and technology play a major role in development debates and policy and in society more generally. As an institution, science has grown exponentially since World War II in terms of the number of people entering scientific fields, the level of scientific output, the number of professional scientific organizations, and the amount of money spent on research (Bucchi 2002; Drori et. al. 2003).[9] More than an increased presence, though, science in the

[9] The institutionalization of science began before the twentieth century. As Schott (1993) notes, the process began in mid-17th century England with the scientific 'revolution'. However, the present pace, form, and pervasiveness of the institutionalization of science really began following World War II, when the former colonial nations gained political and economic independence and science and policy became linked (Bucchi 2002).

modern world has achieved a level of authority and prestige that, according to some, affords it an almost sacred place in society, one that replaces the function of religion (Bucchi 2002; Drori et. al. 2003).

Connected to the greater presence of science and technology in modern society is the discourse on modern societies as knowledge or information societies (Bell 1994; Castells 2000; Drori et. al. 2003; McElhinney 2005; Stehr 2001; Uimonen 2001). According to this discourse, knowledge and information are the basis of power and domination in the contemporary world. Knowledge has, in fact, been "promoted as a development model by policymakers at both national and international levels" (McElhinney 2005: 751). Not only has the production of knowledge increased dramatically in the last fifty years due to the increased budgets for research, but knowledge has also become more economically important as well. Viewed by Stehr (2001) as the "capacity to act" (494), knowledge is the ability to realize one's own will against those of others, to have one's definition of reality accepted by others. In this sense, knowledge and power are intricately tied together in a self-reinforcing relationship, whereby acceptable knowledge—indeed, those elements of the world that are considered 'true' knowledge—is defined by those with power in order to reify that power.

Economic prestige and domination, then, are no longer based primarily on industrial wealth but on the ability of a country or a group or an individual to produce and disseminate knowledge in the form of innovative technologies and scientific discoveries (Parayil 2005; Stehr 2001).[10] However, the nature of science and technology and their relationship to society is not an uncontested issue. How does science progress? Where does the authority bestowed upon science stem from? Who are the actors involved in scientific knowledge production? And is

[10] Of course, these factors are correlated with wealthier societies, or core countries situated as the greatest producers of science and technology, and those on the periphery reporting lower levels of knowledge production.

scientific knowledge the *only* form of knowledge? These are all issues that have garnered attention. Beginning around the 1970s, the debate over the nature of science has been particularly heated within sociology. At this time, the status of scientific knowledge and its claims to authority began to be seriously questioned (Bucchi 2002; Collins 1983; Yearley 2005).

The way in which science is understood determines, in many respects, how one answers the question 'in what ways will the Internet impact the gendered nature of science in developing areas?' At this point, then, a closer examination of these themes is warranted. I identify three dominant assessments of science: the rational/objective view of scientific knowledge, the institutional/competitive view of science, and the socio-cultural/social construction view of scientific knowledge.[11]

The Rational View of Science

The rational view of science corresponds to the more traditional understanding of the role of science in society. This is the conception of science that has been institutionalized, the science that is to be used by developing areas to modernize. From this perspective, science is a pure form of human knowledge, one that is based on a progressive and empirical understanding of the natural world. According to this view, there are two features of science that set it apart from other ways of knowing: first it is progressive and second, it is based on empirical evidence (Yearley 2005). By progressive, this definition implies that scientific knowledge accumulates in a specific pattern leading towards a greater understanding of the natural world and thus steering society closer to 'truth.'

[11] These three 'perspectives' are far from perfect. The sociological study of science is a fairly diverse field and the distinctions between different perspectives have been variously understood. Callon (1995), for instance, argues that there are four distinct views of scientific knowledge and its progression: the rational view of science, the competitive view, the socio-cultural view and the extended translation view of science. For the purposes of the present discussion, three perspectives should be adequate to capture the variation within historical perspectives of science in society.

However, it is the second part of the definition that is the crux of what makes science special. According to the adherents of the rational view of science, the manner in which knowledge is produced is through the objective understanding of one's perception (Drori et. al. 2003). Knowledge is inherent within nature itself and only requires a group of specially trained researchers who know how to interpret their senses in an objective/correct manner. Science, therefore, progresses as the actors involved in the production of scientific knowledge refine their methods and are better able to observe and interpret what has been there all along. In essence nature speaks through them…they become "statement utterers" (Callon 1995: 32). The materials used (and developed) by the scientific community in order to quantify what they observe are seen as "necessary for peering into reality, but hardly formative of the contents of knowledge itself" (Clarke and Star 562).

The scientific method of gathering data and making observations separates science from the social, the political, and the theological. The knowledge produced from the application of the scientific method, consequently, is superior to other forms of knowing because it is unbiased and void of normative influences (Callon 1995; Merton 1973). The social or political are, in fact, perceived as pollutants under this perspective (Shapin 1995). If, at any time, the influence of the social on scientific knowledge is made apparent, it is taken as an instance of failure on the part of the researcher or research team to properly conduct their investigation. The objective and value-free nature of the knowledge produced has thus been compromised, but science as an institution remains intact. From this understanding, it makes sense that science should be afforded a certain status in society and the knowledge produced by it, a certain influence. The unquestioned authority of science, however, began to be challenged with the wider move in sociology away from functionalist theories more generally.

The Competitive/Institutional View of Science

By classifying scientific knowledge as a unique way of knowing, the institution is effectively removed from the gaze of sociology and consequently, it tells us very little (Shapin 1995; Stehr 2001). Robert Merton, often referred to as the founder of the sociology of science, opened the way for sociologists to examine science as a social enterprise. Prior to the 1960's, the sociology of science, as established by Merton, concerned itself with "scientists, scientific institutions, norms, awards, and other forms of stratification" (Clarke and Star 2003: 540). The institution of science, according to this view, is governed by a set of norms and values (universalism, communism, disinterestedness, and organized skepticism), which act to define the correct behavior for scientists as well as to advance the field in general in a relatively progressive manner. These mores, "derive from the goal and the methods" of science itself (Merton 1973: 606). In other words, the institutional imperatives of science exist because they enable science to achieve its goal of increasing knowledge by guiding researchers conduct in a way that is favorable to this goal (Bucchi 2002; Merton 1973; Yearley 2005). In this way, science is conceived as a social system in that it is guided by values and norms, but it remains a unique cultural form because of these very norms.

While the normative structure of science may function to, in a sense, keep researchers in line, this does not mean that these norms are strictly adhered to. In fact, counter-norms are actually quite functional themselves, in part because researchers are in competition with one another for rewards such as prestige, position, and pay (Callon 1995; Collins 1983). Through research and publications, scientists not only advance the knowledge base of the field, but they are also recognized as leaders in their area, as worthy of praise from their peers. As such, there may be times when it is more appropriate for a researcher to ignore the norms of science and

instead act in a particularistic, secretive fashion. By doing this they ensure that they remain competitive and are thus able to survive in their respective field (Callon 1995; Merton 1973). However, the core of science is not threatened by these counternorms. They function in much the same manner as the norms by ensuring that scientific knowledge advances at a steady pace.

Just as in the rational perspective, the *content* of scientific knowledge remains outside of the view of sociology, as do the interactions of the scientists themselves (Bucchi 2002; Callon 1995; Collins 1983). Scientific knowledge is still external to society, a function of nature giving up her secrets to those who know how to understand them. While Merton's theory has been roundly criticized as identifying science as it ought to be or an ideal science, he did open the way for sociologists to critically examine science as a "social subsystem which related to the rest of society" (Bucchi 2002: 14). In many ways, he acted as a platform from which the relativists could jump.

The Social Constructionist View

The social construction view of science encompasses a wide range of theoretical arguments about the sociological study of science and scientific knowledge. Although there is a good deal of variation under this perspective, there is general agreement on two ideas. First, the social constructionist view of science examines those areas left untouched by both the rationalist and the competitive/institutional perspectives by investigating the way in which science works as a "collective good and its application as a collective process" (Shapin 1995: 302). In a sense, it opens the door to the backstage of science, before a piece of knowledge has been 'black boxed' (Latour and Woolgar 1979; Latour 1984).

Second, this perspective does not take the uniqueness of scientific knowledge for granted. Instead, it questions and in some instances flat out denies the exceptionality of the knowledge

produced by science. Knowledge is produced by the collective actions of researchers, policy makers, and funding agencies. Knowledge, just like any other cultural artifact, value, or belief, is created and maintained through social interaction, through the mundane conversations and observations individuals engage in everyday: it is socially constructed (Bucchi 2002; Callon 1995; Collins 1981, 1983; Knorr Cetina 1995; Latour and Woolgar 1979; Latour 1984; Shapin 1995; Yearley 2005). Just as people learn the roles associated with their various statuses, they learn what are and are not acceptable forms of truth or reality (Shapin 1995). [12]

The transition from the approach taken by Merton to the social construction approach, according to Bowden (1995), occurred along two breaks. The first splintering between the two perspectives occurred in the mid-60s and concerned the place of technology in society. Specifically, this represented a break from the idea of technologies as neutral tools, and replaced it with the idea of technologies as "complex enterprise[s] that take place in specific contexts shaped by and in turn shaping human values" (Bowden 1995: 70). Using case studies ranging from the explosion of the Challenger (Collins and Pinch 1998), to the building of levees (Bijker 1995), to examinations of the way in which social roles and statuses impact a person's relationship to technology (Wajcman 1995), studies of technology and society argue that at all phases of development, a technology is not independent of the context in which it is built.[13]

[12] The argument that scientific knowledge is socially constructed, should not be taken too far to indicate that science is nothing more than a social construct and therefore not valid. Examining the social influence on knowledge production does not suggest that any claim can be presented and accepted as fact or that material objects do not exist until the community of scientists constructs them. Instead, the social construction view of science maintains that the material object does physically exist before its 'discovery.' The distinction, though, is that it does not exist as truth or as reality until it is constructed in a certain way (Knorr Cetina 1995). At any given time, certain claims are more likely than others to be accepted because, in part, of the cultural and social context in which it is embedded. There are limits, in other words, to the openness of interpretive flexibility. Knowledge is dependent on the social world for its creation, acceptance, and dissemination. What people are ready to believe determines to an extent the type of knowledge created (Collins and Pinch 1993).

[13] Bijker (1995) elaborates on some distinctions in approaches to technology and society. According to him, there are three themes which examine this topic: the systems approach, the actor network approach, and the social construction of technology approach.

The second break from the competitive/institutional view of science occurred in the mid-70s and is associated with the field of science and technology studies referred to as the sociology of scientific knowledge (Bowden 1995; Collins 1983). Under this perspective, a number of approaches for studying science and scientists have been developed including controversy/extraordinary science studies (Collins 1981; Collins and Pinch 1993), laboratory/normal science studies (Knorr Cetina 1995; Latour 1984) and studies of social worlds/arenas (Clarke and Star 2003), to name a few.[14] The first two perspectives are particularly interesting for a discussion of science in developing areas. Controversy studies, as the name suggests, explicitly focus on the way scientific evidence, before it has been accepted as fact, is open to interpretation or what is referred to as the interpretive flexibility of scientific knowledge (Collins 1981; Collins 1983; Collins and Pinch 1993; Yearley 2005). However, there is a point at which the interpretive flexibility of a piece of evidence reaches its limit, and one camp or another wins out in the debate over what is the correct interpretation of the scientific data under evaluation. The process by which scientific evidence moves from being a controversy to being an accepted piece of scientific knowledge involves social forces, not simply nature making herself known.

Both controversy and laboratory studies examine knowledge that is in the "process of being constituted" (Knorr Cetina 1995: 141). Laboratory studies—emerging around 1979 with the publication of Latour and Woolgar's (1979) *Laboratory Life*—rather than adopting the descriptive approach taken in controversy studies, follow scientists in their day to day routines in order to see for themselves the process by which science is created (Knorr Cetina 1995; Latour 1984). Unlike the perspective outlined by Merton or the rational perspective, "context-specific

[14] These approaches all overlap. At their core, they argue that scientific knowledge is open to observation and that the actors involved in the production of science are inextricably linked to the end result.

contingencies [shape] how scientists…interpret data, use machines, conduct experiments and judge validity" (Henke and Gieryn 2007: 3). Place and context are important for the knowledge that is eventually produced. Science, from this perspective is constructed through the negotiations between actors both within and outside of the laboratory. Actors outside of the laboratory often play as much of a role in the construction of scientific knowledge as the scientists themselves. Funding agencies, political interests, equipment manufacturers all contribute to the way scientific knowledge is constructed (Clarke and Star 2003; Knorr Cetina 1995).[15]

Although the three perspectives take very different views on the nature of science and scientific progress, according to Drori et. al. (2003) they are really part of the same package. The first two perspectives account for science after it has been institutionalized. In other words, the dominant perception among people, organizations, groups, and policy makers may be that science is both universal in the knowledge it creates and functional for the workings of society. As such, the institutionalization of science should not be surprising. It is simply understood as a superior way of seeing the world, as a reflection of and a means to reach modernity. These features of science, however, are endowed after it has been validated as the correct way of seeing the world. To use the functionality of science or its inherent ability to 'get at' the truth of the natural world to explain why it is so pervasive is to use the features of an institutionalized science to explain its institutionalization. It tells us a good deal about what it means for science to be so pervasive and authoritative, but not how it came to be that way.

[15] Actor Network Theory (ANT) argues that nonhuman actors also should be included in the analysis of negotiations (Latour 2005). This theory removes some of the importance of place by suggesting that the focus for science studies should be on the flows of "heterogeneous actants through networks" (Gieryn 2006: 5) thus resembling some of the arguments discussed in theories of globalization on the rise of networked societies and the increasing placelessness of the modern world.

The other component of this package, the social construction of science perspective, opens up the black boxes that the previous two perspectives merely take for granted and in this way is able to identify how science socially constructs a specific reality (Drori et. al. 2003). While science and technology studies is a vast field with an array of intellectual and theoretical schools, the important point is that the sociology of science provides the means to examine the place of science in society, its role in social change, and the manner in which science is produced. It highlights the fact that science, like any other social institution is subject to wider economic, political, and social forces. The manner in which science and technology have developed is historically and culturally specific, and in this sense, it is not necessarily a natural or inevitable outcome.

The understanding of technologies role in society has undergone a similar transformation as that related to sciences role in society. Somewhat more recent than studies of science and society, the relationship between social change and technological change has shifted from what some viewed as an overly deterministic view of the relationship between technology and social change to a social constructivist view of technology. According to the argument of technological determinism, technologies exist as if in a vacuum, as something outside of society, or at least as something that is separate from society. Within a technological determinist framework, there is a one way flow from technology to society so that in this model, technology shapes and influences social change. Changes in communication technologies, then, have created transformations in social relationships. Not the other way around. There is very little consideration for an opposite effect within this model.

From this perspective, then, the fact that highly developed countries are responsible for the majority of scientific and technological output is not inherently problematic, at least at a

theoretical level. After all, "if the direction of advance, the scientific and technological priorities and the methods of solving scientific and technological problems, *were independent of where the work is carried on*" then it really would simply be a matter of transferring technology from wealthier to poorer countries (James 2007: 16). However, if one adopts the view of Bijker (1995), Wajcman (2007), and many others that social relationships of power and inequality directly shape the outcomes of technological change, one is forced to confront the possibility that technological transfer may be inappropriate for generating economic and social progress outside of those countries from which the technologies originated.

Given the argument that science and technology are intricately embedded within the social milieu, that they are not neutral or value free consequences of creativity and design but are imbued with the values of the culture in which they are practiced and produced, Western technologies may be inappropriate outside of the context in which they were developed. Indeed, not only does global research and development concentrate in already wealthy countries, but because of this, what is produced, the problems research and development are designed to address, and the solutions to those problems are all designed with wealthier countries needs in mind. The impact of social relations on technology goes beyond ones position of power or subordination within the world economic system and extends to include gender, class, and race within countries. I now turn to examining issues of scientific and technological inequality based on the categoric unit of gender.

Empowering the Marginalized

A Gender Perspective on Science and Technology

The literature examining science and gender can be divided into three topical areas: women in science, scientific constructions of sexual difference, and the uses of gender in

scientific constructions of subjects and objects (Keller 1995; Schiebinger 1999). The approach taken here is on women in science. In other words, I examine women's scientific careers, the similarities and differences emerging between their careers and the careers of their male counterparts. As mentioned previously, Merton, (1973) writing on the culture of science, argued that the discipline operates according to universalistic standards and values whereby the achievement of an individual within the field is determined not by subjective factors, such as gender, race, or connections, but according to his/her displayed ability. Within the context of the functionalist view of science as espoused by Merton, much of the early literature attributed the unequal position of women in the research career not to science but to gender inequality outside of the walls of academia and research.

If, as argued from the standpoint of the institutional/competitive view of science discussed above, the norms and practices of science operate according to universalistic standards, eliminating particularistic biases, then naturally one should look outside of science to explain gender inequity. Given that women bore, and to a certain extent continue to bear, the bulk of the responsibility for domestic duties, in combination with cultural norms which construct science and engineering as masculine fields, it should be no surprise that women represented a minority of science and engineering students, faculty, and researchers.

The explanation for women's position in the discipline (in terms of the actual number of women, their rank, their productivity and their pay), while possibly due to the culmination of a lifetime of inequality or to familial responsibilities acting to impede their full participation in scientific careers, was not located within the substance of science itself (Cole and Cole 1967; Cole 1979; Cole and Zuckerman 1984; Schiebinger 1999). Differential career outcomes resulted from career performance or an inability to access the institutions of science (Wajcman 2007;

Wajcman 1991). In other words, the gender stratified nature of science was attributed to the position of women within the larger social structure. The solution, then, was to change the gendered socialization process so girls and women would see science and engineering as appropriate careers. Policies designed to create more opportunities for women in primary, secondary, and post-secondary education needed to be created. The solution was to 'add women and stir.'

This perspective, identified as the liberal feminist approach to science, has been heavily criticized. Researchers writing on the gendered nature of science suggest that the argument presented above essentially amounts to blaming women, locating the problem within their socialization and their normative systems. These critiques argue instead that the disparities existing within scientific specialties point to the application of particularistic standards by which ascribed characteristics, such as sex and race, are themselves employed as a basis for stratification *within* science (Long and Fox 1995). As such, it is not enough to simply add women, and let the rest take care of itself. Instead, the solution to the 'woman problem' in science was to dramatically alter the very nature of science itself in order to make room for a different kind of science, one based on so-called women's values and experiences (Sheffield 2004; Wajcman 2007; Xie and Shauman 2003). Known as the standpoint approach to women and science, adherents to this perspective argue that science and technology are built upon masculine values and masculine ways of relating to the world. In order to make science more attractive to women, science should be made less competitive and objective (masculine values). In place of these values, science should be more subjective, holistic, and empathetic (feminine values).

This perspective too has been widely criticized due to its tendency to ignore the socially constructed nature of gender roles. To suggest women's values revolve around subjectivity and men's around objectivity doesn't address the way in which masculinity and femininity are, to a degree, products of socialization and interaction. A second conceptualization, less philosophical, analyzes women in science from a pipeline perspective (Xie and Shauman 2003). Science from this approach is viewed as a pipeline beginning with primary education and extending into the career. If one were to track the scientific pipeline, he/she would note a number of points where women tend to leak out of research career paths. The implications of this model is that in order to increase the numbers of women in science and engineering careers, policies must be implemented which stop the leaking of women from the pipeline. This approach too has been criticized for its rather rigid view of the scientific educational and career path. It also doesn't account for the influence of roles and statuses, pressures and life events that may differentially impact men and women. A fourth approach, the life course perspective, examines the research career within the context of women's lives, not as an entity unto itself.

The question related to gender and technology is formulated in two ways. The first is a more traditional approach to the relationship between technology and society in gender and that is to ask, what impact does technological change have on society? More to the point, what is the differential impact of technological change on women as compared to men? Also referred to as technological determinism, this approach regards technologies themselves as largely value neutral, in a sense existing outside of the social structure rather than within it (Wajcman 1991). Much of this literature, while acknowledging a differential impact of technology on men and women's lives, equates any gender disparities in outcomes to larger gender inequities within the social structure.

A second approach to examining the relationship between gender and technology is to critically examine the technological artifact itself as a historically and culturally specific product. In other words, this approach asks the question, 'in what way are social factors implicit in technological change?' As I noted in the previous section, studies of technology and society have taken a turn from a focus on technologies as value-neutral and separate from social context, to an examination of the socially constructed nature of technology. Given that technologies are not free from the context in which they are produced and used, this understanding of technology and society carries with it implications for women as developers, users and beneficiaries of technology.

Around the 1970's, a number of feminist thinkers including Keller (1995), Morgall (1993), and Wajcman (1991), reacting to the traditional view of technology as inherently neutral and value free, posited that because technologies are shaped according to existing social relations, their use will reflect the inequalities present in any given society. In other words, gender inequity in production and reproduction leaves its fingerprint on the outcomes and consequences of technological development (Morgall 1993; Wajcman 1995).[16] Much of the existing feminist assessment in this area argues that certain technologies work to maintain the oppression of women due to the embeddedness of technology in the capitalist and patriarchal system (Morgall 1993).

According to those who adhere to this perspective, the assumption that technologies are constructed in a value-free manner is not only false, but in a certain sense dangerous as it overlooks the fact that "how we use technologies…whether a particular technology brings benefits or burdens, and to whom…is very much influenced by who we are: what gender, class,

[16] To some, all technologies exhibit the dominant values of a capitalist and patriarchal society, as such, the problems and solutions offered by science and technology are framed from within a masculine perspective (Morgall 1993).

and race we are and where we live" (Kirkup & Keller 1992: 1). In an attempt to rectify the traditional position, feminist thinkers argue for the placement of current as well as past technologies in their historical and social contexts in order to better grasp the manner by which they have been used to advance the goals of certain groups, often to the disadvantage of women, minorities, and Third World cultures.

Morgall (1993), building on Bush's (1983) model of technology assessment, proposes that technology be examined in five contexts: the design or development context, encompassing all aspects of the creation of technologies; the user context encompassing the motivations, advantages and costs of using technology; the environmental context encompassing the general physical atmosphere in which technologies are developed and used; the cultural context encompassing the values, norms, beliefs, and laws of the society in which a technology is developed and used; and finally the socioeconomic context encompassing the social and material conditions "influencing development, dissemination, and end-user conditions" (Morgall 1993:135). The point being that the way a technology is used by women will not be consistent with expectations and will have unintended consequences because women—and men—will use technologies in a way that is consistent with the social, political, economic, and cultural environment in which they live and work. Ideally each of these contexts would be examined in order to more accurately assess the impact of technology on women's scientific careers. Indeed there are a number of examples of this kind of work available (Abbate 2000; Wajcman 1991). For this dissertation, however, I only indirectly examine these contexts.

The main theoretical point, though, is that by placing technologies within there social and cultural context, one is able to better observe the "economic and social class interests [that] often lie behind the development and adoption of devices," a feature missing from earlier observations

on technological developments (Wajcman 1991:23). The class and gender inequalities at the national and global levels must be considered when assessing the utility of technological developments, particularly the manner in which these developments impact the lives of women. This is not to argue that women are simply passive recipients and consumers of inherently masculine technologies or that technology has not been beneficial to women. To the contrary; if scientific knowledge and technological advances are products of the society in which they emerged and their use and organization express the values, goals, and ideals of that society, then women can impact the outcomes of technological design and development. Indeed, it has been demonstrated that once a technology is developed it is often used by women in ways unexpected by the original designers (Wajcman 1995).

Essentially the question being asked when discussing gender and technology is, 'will new technologies lead to a change in cultural understandings of gender roles and subsequently to changes in the social structure?' For women with research careers in less developed areas, the question basically remains the same, but the answer is not. The universal value of ICTs and scientific knowledge must be considered from within the power-knowledge nexus. In order to understand the relationship between gender, science and technology and social change in Africa and Asia, this relationship must be understood within the historical context of development and within the current discussions of globalization and the digital divide.

In sum, while access to technologies may lead to an initial period of resource distribution in the scientific career, it is unlikely to lead to sustained change due to the fact that gender status beliefs are slow to follow changes in resource distribution. As such, while gender status beliefs in one area may be challenged repeatedly leading to changes in gender inequity, new interactions and situations will lead to further gender status beliefs and as a consequence continued gender

inequality. Is it possible, however, that the Internet may ease the impact of sex categorization on gender status beliefs and resource differentials because interaction is mediated through technology. In other words, is it possible that interactions that occur through means other than face-to-face may enable male and females to ignore the gendered expectations they have for self and others? Research demonstrates that even with computer mediated interaction actors continue to sex categorize and use this to inform their judgments of self and others (Ridgeway 1997). In fact, some studies suggest that without the normative constraints of standing in front of a person and have the immediate feedback that results from negative behavior, computer mediated interaction may allow actors to feel more comfortable displaying their gender status beliefs.

Gender in Less Developed Areas

While the development discourse emerged in the post World War II era, it took another thirty years before the subject of women in development entered the discussion. The development discourse not only created a one size fits all approach to the different regions classified as developing, but also within the countries themselves. The impact that development programs had on different people based on their class, race, ethnicity, or gender was not considered in the design of these programs. Women were, almost without exception, excluded from the development discourse until the 1970's due to the popular opinion that they were predominately involved in the domestic and unpaid sphere, whereas men dominated the public life of paid work and were thus most affected by development programs (Acosta-Belen and Bose 1990). Before the focus of development shifted, then, the literature relegated women to the 'non-productive' sphere. Viewed as domestic workers first and foremost, the work done by women was not considered important to the process of *economic* development.

Today, within the broad frameworks of gender and development (GAD) and women in development (WID), this vacuum is being filled. Roughly corresponding with the women's movement in more industrialized countries, beginning around 1975 there emerged a call to bring women into the development framework (Acosta-Belen and Bose 1990). Since that time, the issue of bringing women into the development discussion has taken a number of turns, including the welfare approach, the human resource approach, the anti-poverty approach, the efficiency approach, and finally the empowerment approach (Snyder and Tadesse 1995).

Much of the current literature examines the topic from within the empowerment perspective, concentrating on ways that women in less developed countries can create economic and social independence for themselves. The evolution in the literature on gender and development from a focus on welfare to a focus on empowerment is significant, particularly for this discussion. This shift marks a greater move from top down approaches to development, to bottom up approaches which stress the importance of grassroots movements and the representation of women in the designing of development policies and strategies. Most writers, when speaking of the empowerment of women in developing areas, are referring to increased political, social and economic opportunities for women through the creation of "enabling mechanisms that empower women to take control of their lives" (Ramachandran 1998:58; Mitter 2004). These writers frequently argue for the participation of women in grassroots movements with a decentralized power structure.

Within the development literature, ICT are frequently viewed as an empowering technology (Mitter 1995) due to the ease and accessibility of information and knowledge through the Internet. With the widespread advancements in the production of information and communication technologies (ICTs), this goal has taken on a new dimension, one in which the

activities of women may be capable of moving beyond the boundaries of space and time, linking women separated by states, countries, and even continents (Huyer and Carr 2002). However, this notion of empowerment through technology has little empirical support behind it and largely relies on anecdotal evidence. Furthermore, the empowerment debate sounds remarkably similar to the modernization debate; the argument being to provide women with the technologies and they will empower themselves. Each of the perspectives regarding the nature of development, the historical reasons for its emergence as an ideal, and the consequences of the process, particularly for women, provides limited insight into contemporary trends. As such, new, more contemporary, insights are needed.

A Global Science

Computer Networks as Social Networks

Institutional theories hold that science is a global enterprise; it is part of the global cultural framework. Indeed, some argue that the shift in science from little to big is now giving way to a science based on global networks or global invisible colleges (Wagner 2008). Generally speaking, however, less developed countries are not participating fully in the practice of science in terms of common measures of involvement. Researchers in these areas produce less, and they are not able to fully access and use technological and financial resources (Frame et. al. 1977; Frame 1980; Gaillard 1991). The most advanced research systems are situated in those countries with the strongest economies. Actors employed in the premier universities, research organizations, and funding agencies located in the United States, Western Europe, and certain Asian countries define the goals of science, its organization, and the important, 'hot' topics. They set the scientific agenda. These disparities become especially pronounced when one considers the gender make-up of the scientific community.

But even still, it is undeniable that scientific participation has increased at all levels since mid-century; in both developed and less developed areas and in terms of women's participation (Drori et. al.2003; Gaillard 1991; Gaillard et. al. 1997; Shahidullah 1991). In addition, even highly functioning scientific systems are stratified. The elite researchers, the most productive and visual, are a minority. Given the trends associated with globalization, the spread of communication technologies, and the movement of people around the globe, the study of science and development needs to be approached with methodological and theoretical stances that account for the global nature of scientific interactions. It is inaccurate and an oversimplification to categorize the nature of science as one of core vs. periphery or connected vs. isolated. A more nuanced approach is necessary in order to understand the production of knowledge in the 21st century. A social network analysis provides a useful methodological approach for analyzing the "interlocking set of individual and organizational interactions which propel world technoscience" (Shrum and Shenhav 1995).

The social network perspective refers to a few rather basic but powerful propositions regarding the nature of social life: actors are embedded within a network of ties to others, and these ties directly constrain or enable the ability of an actor to act because links between actors serve as a conduit along which resources (information, power, wealth) travel to and from members of a network. At any given moment, every human being, group, organization, community, and country is embedded within a network of ties with others. These ties represent relationships, relationships based on politics, economics, family, friendship, professional collaboration, etc.

From a network perspective, behavior is not solely the consequence of internalized cultural norms or individual attributes. Instead, a network approach views human behavior as

being constrained or enabled by social ties. The pattern of an individual's or an organization's links with other individuals or organizations predicts the outcomes of social action (Friedmann 1988; Marsden 1990; Scott 1991; Wellman 1988). A variety of questions have been examined using a network approach: What predicts the success or failure of a job search? Why are some individuals more successful at starting a new business? How does technology diffuse and what predicts adoption? Why are some researchers more productive than others? By focusing on the gendered nature of professional networks within global science, this study moves from development discourses centered on the idea of bounded identities and places defined by level of industrialization, to examine the boundary crossing of internal and external links and the manner in which they interact with one another.

Approaches to social network analysis typically fall into two camps: the whole network approach and the ego-centered approach (Marsden 1990; Rogers and Kincaid 1981; Shrum 1997; Shrum and Bankston 1993/94; Shrum and Beggs 1996; Wasserman and Faust 1994). The former perspective on social networks attempts to map all ties between individuals, groups, or organizations within a specified boundary or belonging to a specific population. This approach provides a means of measuring social structure by modeling the relatively stable and patterned relations between people, groups, and institutions. In a sense, the whole network approach reasons downwards, analyzing structural features of networks in order to make statements about the nature of ties and clusters within the network. The ego centered approach, rather than mapping all social relations within a specified boundary, is concerned only with the ties between a focal individual (often referred to as 'alter') and his/her contacts. This is a more bottom up approach in which a researcher describes the nature of ties and clusters to make statements about

the structural features of a network (Wellman 1983). It is the ego-centered approach that I adopt in this dissertation.

Within either approach, there are two closely related dimensions of social networks that are integral to understanding the overall perspective: network *structure* and embedded *resources* (Hurlbert et. al. 2000; Marsden and Hurlbert 1988; Lin 2001: 3). The basic proposition behind network analysis is that an individual's social relationships have a distinct composition or structure defined by the complex web of ties between actors (egos) and alters (Rogers and Kincaid 1981; Scott 1991). There are a number of different measures of network structure including three of which are of importance for the present discussion: 1) network composition; 2) range; and 3) tie strength.

Network composition, or the characteristics of an actor's contacts, is measured by the average traits of actors on such measures as race, sex, age, religious affiliation, education, income, geographic location, and whether the ties are ascribed or achieved i.e. kin or non-kin (Rogers and Kincaid 1981; Wasserman and Faust 1994). Defined as the number of contacts with diverse others, range is a measure of the sociodemographic distance between social actors within ego's networks (Ibarra 1993; Marsden 1987; Marsden 1990: 455). Range measures the degree to which a person's social network connects him/her to diverse others.

There are a number of empirically distinct measures of range. They include the size of an actor's network or the number of direct ties between ego and alters. Perhaps a more direct measure of range is diversity itself. In this regard, one can measure the diversity of an actor's networks on a number of dimensions including the gender and geographic diversity of one's social ties. The principle of homophily, or the notion that contact tends to occur more frequently between individuals located closer to one another in sociodemographic space, is one of the most

salient findings within the social network literature (Ibarra 1993; McPherson et. al. 2001). Very simply, social actors, through a combination of opportunity and active choice, associate with people who are like themselves. Measuring diversity differs from measures of homophily and heterogeneity in that range conceptualizes diversity as similarity or difference among egos contacts *not* between ego and alters (Ibarra 1993).

Another important structural measure of social networks concerns the nature of the relationship between ego and alters. In particular, the strength of the ties between network members has been conceptualized as one of the more important factors effecting outcomes of action. The strength of ties acts as a measure of the intensity of contacts between actors in a network in terms of the frequency of contact and the emotional closeness of the relationships. Since the concept was first formulated by Granovetter (1973) in his article 'The Strength of Weak Ties,' it has garnered much attention as an important structural dimension of social networks for predicting mobility outcomes, particularly in the career. A number of approaches have been developed to measure the strength of the ties between ego and alters including the

> "extent of multiplexity within a tie, the duration of the contact, the provision of emotional support and aid within the relationship, the social homogeneity of those joined by a tie, the overlap of memberships in organizations between the parties to a tie, and (for closed populations) the overlap of social circles" (Marsden and Campbell 1984: 484).

The importance of social networks lies in more than simply the structure of a person's ties. Specific network structures (in terms of the composition, range, and strength of ties) between an actor and his/her contacts indicate the types of resources one is exposed to and consequently the probability of successful outcomes in instrumental and expressive action. [17]

[17] Although I do not deal directly with resources in this paper, it is important to have an idea of what is meant by the term. Two commonly analyzed resources, formal and informal social support and access to information are likely to be particularly useful for researchers (Hurlbert et. al. 2000). Resources include any number of things but within science some of the important resources embedded within a person's professional networks are information,

Based on the shape of the social network, or egos position relative to a number of alters, an actor is exposed to contacts possessing varying degrees and kinds of resources. In other words, at any time, actors, with varying degrees and types of resources, are embedded in a network of relations with others who also possess varying degrees and types of resources (Lin 2001). Ties with alters possessing a certain type and degree of resources increase the likelihood of certain types of behaviors and actions while at the same time closing the likelihood of other outcomes. Although the data used for this dissertation does not directly measure the types of resources exchanged, the notion of resources is integral to understanding the importance of social ties. Further, based on the structure of researcher's professional networks, one can impugn—cautiously—about the types of resources available.

A network approach is particularly relevant in the context of science in less developed areas. The primary interest of this dissertation is to determine to what extent new ICTs are being used by researchers in less developed areas to incorporate themselves more fully in the world scientific system in two respects: one through incorporation in professional network structures and two through changes in productivity patterns. Shrum and Bankston (1993) identify two trends within the literature examining *technoscientific* networks: the geopolitical approach and the organizational approach. The geopolitical approach is encapsulated in Schott's perspective.

Schott (1993) identifies three levels of nested scientific integration starting at the individual level or the collegial circle. This level includes those researchers one is in contact with everyday, and they act as a reference point for an individual researcher. While certainly including colleagues within one's department and university, this level also may include those colleagues at other *local* universities, within the city or possibly even state. The collegial circle

---

expertise, professional advice, and material resources, etc…It can also include more informal things like networks of professional support, gossip circles.

of researchers is embedded within the national scientific community or those people beyond the local level but within the same country. Researchers one meets at regional and national conferences, for instance, would likely be included at this level as would faculty members at other universities one knows from graduate school or from past employment history. The final level, the global scientific community, includes those ties with researchers that cross national boundaries encompassing an international web of contacts. For researchers in Ghana and Kenya this would include researchers not just abroad in the United States, Europe or Asia, but also researchers in other African countries. Global science refers to more than just the ties between researchers in different nations, but it is this aspect of a global science that the Internet may be able to facilitate by providing a means for academics and nonacademic alike to connect without the expense associated with co-presence. Another approach is to examine intra and interorganizational networks, by focusing on the ties between researchers located in different organizations and between researchers within the same organization. Such an approach can explicitly examine professional ties from ego to individual alters or ties between ego and organizations.

In the context of the information age, much has been made about the relationship between technology and social networks. Recent research by Wellman (2001) and Wellman et. al. (1996) argues that computer networks are social networks. Computer use, particularly the use of email, instant messaging, and message boards, are not just connecting nodes, they are connecting people who turn to online relationships seeking support, information, and commonality from others. Mediated communication is, of course, nothing new. People have been writing letters, sending telegraph messages, and telephoning one another for decades, longer in regards to letter writing. What *is* new is the variety of technologies available for

communication purposes and the ability to use new technologies from most any location at most anytime. In the era of globalization, people use technologies to maintain relationships and interactions with absent others. In this way "social ties and social networks are embedded in a web of interaction-supporting artifacts" (Licoppe and Smoreda 2005: 319). Through the use of mediated communication through ICTs, social networks have been decoupled; more so than at any other point in history, from face-to-face, co-present interactions (Gjerde and Cardilla 2005).

The discussion in this regard tends to revolve around two questions: one, how does the shape of a person's social network impact adoption of innovations like the Internet, email, and mobile phones; and two, what are the consequences of technology adoption for the size and shape of social networks? In other words, the nature of the relationship between technology adoption and social networks is a circular one. Some networks provide earlier and easier access to information about new innovations promoting adoption, but at the same time adoption of technology may alter network structure. Likewise, the relationship between productivity and social networks and even Internet adoption, for that matter is certainly circular in nature. Certain network structures may lead to higher productivity levels but the argument just as easily flows in the opposite direction: being more productive may lead to researchers possessing larger, more diverse, less homophilous social network perhaps because they are engaged in more cutting edge research causing them to be more visible within the scientific community. Both issues are important, but this dissertation is primarily concerned with delineating the impact of new technologies on social network size and from there, the impact of new technologies and social networks on productivity.

Time, Place, and Gendered Identities: Development as Reagency

Historical perspectives regarding the nature of development do not adequately capture what is occurring in those countries classified as Third World, developing, or less developed. Each of the perspectives discussed above assume either a passive acceptance of modernity or a centre-periphery dichotomy of negotiation and exploitation. Globalization may not entail the disappearance of national borders, but these borders are certainly more fluid than Wallerstein's world systems theory would suggest. Modernization, dependency/world system, and neo-institutional theories of social and economic development are unable to account for the role of place and identity in developing areas. Culture is largely missing from these analyses because of their attempt to generalize the process of social change. For a more accurate understanding of the development process, we need a new means of looking at development and globalization; a way of understanding the processes playing out in unique geographic and institutional settings.

Furthermore, these theories, because they predate the widespread advancements in and diffusion of ICTs, are unable to account for the nature of contemporary social changes occurring throughout the world (Castells 2000; DiMaggio et. al. 2001; Uimonen 2001). The Internet, as a key factor in the current accelerated globalization, represents a challenge to the way development is conceived. It has, in effect, rendered the explanations of development provided by modernization and dependency world system theorists problematic due to the potential change in the spatio-temporal implementation of development projects, aid, and technology transfers. For these reasons, Shrum (2005) argues that the notion of development needs to be rethought and understood from the perspective of reagency.

Extending on Emirbayer and Misch's (1998) definition of agency,[18] he asserts that the concept is better able to capture what happens when development projects and policies are disseminated into developing areas, or what he refers to as 'distant lands'. It is not a simple matter of diffusion and adoption or domination and subjugation. Instead, there is a dynamic interplay between development initiatives, place, and identity. When development initiatives make their way into developing areas, they are not entering an empty space. They are entering a place, a unique cultural context made up of the identities of people interacting with one another. In this way, 'development' occurs at a number of levels: at the macro level which includes cultural beliefs and practices of different regions, as well as the distribution of resources; at the interactional level which includes patterns of behavior and organizational practices; and at the individual level which includes the identities, goals, and personalities of the people development initiatives are meant to impact. Gender too, is a multilevel system used for categorizing people and treating them differently based on such categorization.

The placelessness of the postindustrial age, as typified in the hyperglobalist approach, has recently been challenged and the importance of place reasserted (Escobar 2001; Henke and Gieryn 2007; Shrum 2005). From the importance of place in the construction of culture noted by Escobar (2001), to the analysis of emplaced science by Henke and Gieryn (2007), it is recognized by many that "culture sits in places…even if it is by no means restricted to them" (Escobar 2001: 147). While globalization has largely entailed a "reconfiguration of geography, so that social space is no longer mapped in terms of territorial places, territorial distances, and

[18] According to Emirbayer and Misch (1998) agency should be viewed as a temporally embedded process of "social exchange." By temporally embedded, they mean that agentic orientations take three forms: past, present, and future. The outcome of action is dependent on the interaction of these three projective orientations. But, of course, the outcome of social action is not independent of the structural context in which it takes place. However, Shrum (2005) argues that their theory of agency is both "un-placed and un-identified" because, while they examine the temporal aspects of agency, they fail to identify the relational aspect of agency.

territorial borders," this does not mean that globalization equates to pervasive cultural homogenization or what amounts to the same thing to placelessness (Scholte 2000: 16). Identities are still formed in places, through everyday interactions with friends, neighbors, and colleagues; through the social context in which these relations are embedded; and it is formed, to one degree or another, by the increased interconnectedness of the world. A network approach to the study of science in less developed areas allows the discussion to move beyond the weaknesses inherent within the traditional perspectives. In fact, the network perspective explicitly argues for an approach to social life which acknowledges the way in which "structured access to scarce resources determines opportunities and constraints for behavior" (Wellman 1983: 162). As applied to reagency: economic development and lack thereof determines structured access to resources. Aid comes in to such an environment in which people are embedded within a system of ties which they use in a way that is consistent with their local network expectations. But the point is that these are a certain type of tie that is embedded within a larger structural system of ties in which people have obligations to more than just their professional contacts but also to family, friends, neighbors, and political allies. The actors—individuals, groups, and organizations—occupying a given place do not passively adopt a particular development project. To the contrary, development initiatives create a reaction. This is not to say that such projects do not change the nature of the place, only that the change is often not in the expected manner i.e. towards a state of developed or modern.

Of the three perspectives, the multi-dimensional approach of the transformationalist thesis is most congruent with the idea of development as reagency. The transformationalist thesis provides a way of seeing globalization and cultural change that leaves room for variation and more importantly individual actors, and reagency provides a framework for understanding

the implications of the Internet for a global science. The impact of the widespread diffusion and actual use of the Internet in the places of scientific practice in developing areas is intricately tied to those places and the identities of its users. The economic dimension of globalization taken by the hyperglobalists and the skeptics certainly cannot be ignored. The debt restructuring which followed the debt crisis in the 1980s, and the liberalization of world markets around the same time, played a major role in shaping globalization (Stiglitz 2002). But inherent within the transformationalist perspective is the assertion that globalization impacts different domains of social life in distinct ways. In order to gain a fuller understanding of globalization and its impact on domestic social arrangements, the investigation must go beyond a narrow focus on economic integration.

Understanding development as reagency means that we have to understand the way in which identities within a given moment and situated in a specific location and in relationship to some other influence action. An agent, of course, possesses many identities, more or less prominent in any given temporal, spatial and interactional context. Not only does a focus agent have a given identity but so too do the people he/she interacts with and each uses certain physical and behavioral cues to invoke schemas which act as expectations for both how one is expected to act and for what one can expect from another. In sum, the reagency perspective suggest that the relations between "constraints and ICTs are very complex and depend on the socio-physical contexts in which they are situated. Specifically, these relations often depend on the type of activity undertaken, the persons, technologies other material artifacts and the places and times involved as well as the social relations in which people are embedded" (Schwanen and Kwan 2008: 1363).

It is thus essential to incorporate a gender perspective into the reagency account of technology diffusion and development. Sex is one of the most salient categories of social organization. It is a highly visible cue that allows actors interacting with one another to expect certain behaviors and attitudes from self and others thus enabling interaction to occur more smoothly. However, sex categorization also leads to gender status beliefs or beliefs in the competence, power and respectability of the other in an interaction. Ridgeway (1997) describes the process as follows:

> "Some of these schemas must be so simplified and so apparently obvious that they provide an easy means of initially situating self and almost any other so that interaction may begin at all. Such prior categorization systems in effect are cultural 'superschemas' defining a few fundamental categories that can be applied to make sense of any person. They need not be relevant to the specific focus of interaction. They merely render actors sufficiently meaningful to one another to be able to address each other in relation to the focal goals and, by doing so, to introduce more relevant categorizations. Yet, by providing a cognitive starting point from which the rest proceeds, these superschemas can subtly influence the course of interaction even when they are irrelevant to its focus" (220).

These superschemas also provide one with an understanding of self, not merely other and can influence more than interactions with other living beings but also interactions with inanimate objects such as technologies. The categorization of every individual into a gender classification (male, female) in and of itself does not necessarily reproduce gender inequality. But because cultural understandings of gender difference are associated with status beliefs, the salience of sex categorization leads actors to 1) assume the superiority and competence of one sex over another; 2) adhere to an uneven reward distribution system which favors the group who is assumed to be more competent; and 3) reproduce their understanding of gender difference and ignore information that contradicts sex stereotypes (Ridgeway 1997). Such outcomes are especially likely in situations where mixed-sex interactions are common and in which the activity is linked

to stereotypical ideas about appropriate gendered behavior or strengths (Ridgeway and Correll, 2004).

Given the argument of reagency, I suggest that the relationship between gender, professional networks, and research outcomes will not be a revolutionary one but an evolutionary one. Researchers in less developed countries much like their counterparts in more developed areas will likely incorporate the technology into their lives in much the same way that they have past technologies. They will use email and other features of the net in way that complements their lifestyles but also perhaps to support them in new ways that have not been seen before. In the chapters that follow, I present results examining women's access to and use of technology, their professional network structure, and their research outcomes in terms of productivity. Before I do this, however, it is important to understand that social networks are created and maintained within a specific context which acts to constrain and enable men's and women's lives in specific ways. In order to understand the way technologies are used by women to maintain professional relationships, then, a brief review of the locations studied is necessary.

CHAPTER 3: CONTEXT, DATA, AND METHODOLOGY

Context of the Study

The countries chosen for this study were selected in 1994 to represent varying levels of social, economic, and technical development (Ghana—low; Kenya—medium; and Kerala—high). Ghana, the first country in Sub-Saharan Africa to attain independence in 1957, initially seemed to represent a bright spot in comparison to other African countries. Reporting the highest Gross National Product on the continent and a relatively stable political system, many experts expected Ghana to emerge as the leader on the path towards post-independence development. Following an economic crisis in the 1970s, however, much of the initial enthusiasm regarding the country's future waned, and although currently reporting a multi-party democracy, Ghana experienced a number of military coups and did not implement a democratic government until 1992.

The East African state of Kenya, representing a middle level of development, struggled the first three decades after gaining independence in 1963. While stabilizing somewhat, And most recently, the country was thrown into turmoil over the disputed election results held in late 2007. Finally, Kerala was selected to represent the highest degree of development. Located along the southwestern coast of India, the state is famous for what some have called the Kerala model of development. Marked by high levels of social progress and corresponding low levels of economic advancement, Kerala is often discussed in the development literature as a paradox, both compared to other developing countries as well as within India itself.[19]

[19] The Kerala situation goes against the dominant strand of thought in economics, which contends economic growth is needed *before* social development can occur. The characteristic of high social progress and low economic development, combined with a politically active, involved population and radical land reforms comprise the dominant features of the Kerala model of development (Franke and Chasin 2000).

A number of measures are used to rank countries according to level of social development including rates of: literacy, infant mortality, total fertility, and life expectancy. Based on these measures, the ranking of the three areas reflects, with some variation, the social hierarchy originally established in 1994. For instance, the literacy rate, defined as those aged 15 and over who can read and write, is 57.9% for the total population in Ghana; 85.1% for the total population in Kenya, and 90% for the total population in Kerala (CIA Factbook 2000; National Family Health Survey 2005-2006). For measures of infant mortality, fertility, and life expectancy, however, Ghana and Kenya reverse positions with Ghana reporting 51.09 deaths per 1,000 live births and 3.68 children born per woman. Kenya reports slightly higher infant mortality and fertility rates (54.7 deaths per 1,000 live births and 4.56 children born per woman).

The same reversal between Ghana and Kenya occurs for life expectancy with the total population of Ghana living on average 60 years, compared to 58 years for Kenyans. On these three measures, Kerala stands apart reporting only 14.1 deaths per 1,000 live births and 1.70 children born per woman. Life expectancy for Malayalis, on the other hand, resembles that of the population in the United States at an average of 73 years. In sum, not only has Kerala achieved a high literacy rate and high life expectancy in comparison to Ghana and Kenya, it has also produced dramatic reductions in the fertility rate and infant mortality rate. Not only are these measures indicative of access to a more nutritious diet and better health care, but the latter two measures in particular are also indicative of the greater gender equity in the region.

Gender roles in all three regions tend to be dominated by patriarchal systems. Although politically Ghana, Kenya, and Kerala have all taken measures to eradicate gender inequality in family formation, education, and employment most measures from development organizations and NGOs indicate that women continue to lag behind men in a number of respects. From the

type of work that they do to their family responsibilities, women and men in Ghana, Kenya, and Kerala have distinctly different daily activities and social constraints. To begin with, women do distinctly different work than men. Familial responsibility tends to be the domain of women. Women are the kin-keepers. They are the ones who are primarily responsible for raising children and taking care of the domestic chores, such as cooking, washing, and collecting fuel-wood and water.

In a 1996 report issued by the World Bank, it was noted that in spite of the gains women have made in certain areas of life in Ghana, "gender inequalities continue to constrain women's ability to participate in and contribute to the economy, and harm women's health." Only 47% of primary school students in 1994 were girls, 35% of senior secondary students were girls, and only 26% of tertiary school students were girls. In other words, girls in Ghana receive less education than boys. While historically Kenya possessed one of the larger research systems in Africa, in recent years, this system has deteriorated due to corruption and financial problems. The female portion of the country's six public universities, with a total of about 45,000 students, rose to 13,833 in 2001 from 9,334 in 1990; a 48 percent increase that brought women to about 30 percent of total university enrollment, says Kilemi Mwiria, an assistant minister of education. But women are only about 12 percent of students pursuing math and science majors.

Although enrollment and retention within the school system has improved for girls, particularly in Ghana and Kenya, the gender disparities in school performance persist with girls reporting consistently lower math and verbal skills. The persistence differences in performance suggest, in part, that parents may not place as great an emphasis on educating their daughters as they do on educating their sons. Even when girls do make it through the school system to attain higher degrees, the gender segregated nature of the home and workplace may push women into

less prestigious and less well-payed occupations such as which may be why there are relatively few women employed in the research systems of Ghana, Kenya, and, to a less degree, Kerala.

Economic measures of development are varied. Among the more basic measures are gross domestic product (GDP), poverty rates, and unemployment levels. Again, recent economic trends suggest that perhaps the original 1994 ranking placing Ghana at the lowest level and Kenya at the middle level be reversed. Based solely on measures of GDP, poverty and unemployment Ghana's economic situation appears to be relatively stable, while Kenya's may be somewhat more uncertain. According to the CIA Factbook, Kenya's gross domestic product (measured by its real growth rate) was 6.4% in 2006; 7% in 2007, but dropped dramatically to 2.2% in 2008. The corresponding figures for Ghana, on the other hand, are 6.4%, 6.1%, and 6.3%. Again, this seems to suggest (at least for the last year) distinctly different economic paths for the two countries. Although taken from different years, the CIA Factbook reports the unemployment rate for Kenya in 2008 at 40% and 50% of the population were classified as below the poverty line in 2000. The corresponding figures for Ghana are 11% unemployment in the year 2000 and 28.5% in 2007.

At the same time that Kerala reports much better social statistics, both in comparison to the rest of India and in comparison to Ghana and Kenya, historically, the state also reported relatively poor economic indicators (this is really in comparison to India. In comparison to the two African countries, Kerala far exceeds the measures of economic development in Kenya and Ghana). Kerala's gross state domestic product over the years 2003-2004, for instance, was 7.4%, 9.2% over the years 2004-2005, 8% over the years 2005-2006, and 8.1% over the years 2006-2007 (Financial Express accessed 2009; Mohindra 2003). Although rising and falling slightly, the economic figures coming out of Kerala are consistently, though not dramatically, higher than

those for Kenya and Ghana. On measures of unemployment and poverty, the statistics for Kerala are significantly better than for the two African countries. The unemployment rate in Kerala in 2007 was estimated at 9.4%, dramatically less than in Kenya and slightly less than in Ghana (Kumar 2007). The percentage of Malaylalis below the poverty line over the period 2004-2005, furthermore, was 15%; a figure that is, again, substantially better than the corresponding figures for Ghana and Kenya. Despite impressive gains in economic investment and output, India faces pressing problems such as significant overpopulation, environmental degradation, extensive poverty, and widespread corruption.

Finally, in terms of technological progress or development, as the argument of the neo-institutionalists might lead one to predict, all three regions have designed and are attempting to implement ICT policy frameworks, with varying degrees of success. Regarding technology access and connectivity, Ghana, in 2005 reported 18.4 Internet users and 5 personal computers per 1,000 people. Ghana has a higher connectivity rate than many African countries, although it lags behind Kenya. In 2005, Kenya reported a greater diffusion of the Internet and personal computers than Ghana—32.4 and 9 per 1,000 people respectively. The country of India as a whole reported 54.8 Internet users and 16 personal computers per 1,000 people. The same social motivations that produced total literacy may also be positively associated with total connectivity, but questions of consequence remain. Total literacy has not solved the problems that have plagued Kerala in terms of economic well being, and it remains to be seen whether the Internet will do better (Davidson et. al. 2002: 32).

The diffusion of ICT to developing areas creates new possibilities for the role of women in development by eliminating spatial and temporal boundaries. However, although few empirical examinations into the topic of gender and ICT diffusion have been conducted, what

has been done seems to concur with much of the research coming out of other regions of the world. Arun and Arun (2002), for instance, note that while ICTs in Kerala have provided women with increased employment opportunities through such activities as software production, they have also reproduced the larger pattern of gender inequalities present within Indian society.

Sample and Design of the Study

To analyze change in the research career associated with access to and use of ICT, I employ quantitative data that is part of a multi-wave survey of the scientific community in Ghana, Kenya, and Kerala. In total, three waves of data have been collected with particular attention paid to sampling as many female researchers as possible. Beginning in 1994, approximately 300 face-to-face interviews with scientists employed in universities, national research institutes, and non-governmental organizations (NGOs) were questioned about a broad range of educational and occupational issues. Initially, the aim of the sampling design was to select as comprehensive a sample as possible in order to get a broader perspective of the research system in less developed areas. As such, a small number of respondents were selected from each of the types of organizations selected. In the second wave of surveys—beginning in Kerala in 2000, followed by Kenya in 2001 and Ghana in 2002—the aim of the sampling design was to select a larger number of respondents within a fewer number of organizations. As such, approximately 900 *new* scientists employed only in research institutes and universities were interviewed.[20] The survey design used was similar to the one used in 1994 but with the addition of questions related to access to and use of information and communication technologies, specifically related to personal computers, the Web, and email.

The third and most recent wave of the survey took place over the summer of 2005 in all three countries. Efforts were made to interview as many of the respondents from the second

wave (2000-2002) of the survey as possible. In most instances of sample attrition, those respondents no longer willing or able to participate were replaced. In total 860 researchers were interviewed. Of the 860, 540 were interviewed in both the second and third waves of the survey for a completion rate of 63%. Among the panel members, 119 were female and 420 were male. In both periods, 297 respondents were employed in the academic sector, and 242 in research institutes.

The results reported below are based only on the 540 panel respondents.[21] In most respects, the questions on this final wave of the survey resemble those employed in the 2000-2002 wave. There are, however, a few exceptions. First, the 2005 survey included a number of additional attitudinal questions regarding the impact of the Internet on the scientific systems in Ghana, Kenya, and Kerala, particularly concerning the gendered nature of the technology. Second, the 2005 questionnaire included a section pertaining to the use of mobile phones.

Operationalization of Variables

There are seven dimensions of the research career, roughly corresponding to individual/personal characteristics and institutional/social organizational characteristics. These seven dimensions have been identified as important independent and control variables for predicting the career outcomes of female scientists.[22] Dimensions related to the individual/personal characteristics of the research career, consisting of family structure, human capital, localism, contextual factors, and technological antecedents are examined in chapter four. The final two dimensions, related to ICT access and use and professional network structure, are

[20] Appendix A lists the universities and research institutes interviewed in the second and third waves of the study.
[21] Because I am using the panel data, I refer to the 2000-2002 wave as the first wave and the 2005 wave as the second.
[22] The broad distinction between individual/personal characteristics and institutional/social organizational characteristics is a modification of Long and Fox's (1995) article in which they identify a number of factors contributing to differential career attainment between males and females, including: personal characteristics,

examined in chapters five and six and concern more institutional/organizational differences between males and females. In the final chapter of the analysis, I focus on the consequences of the gender disparities on these dimensions by examining career outcomes, specifically in terms of productivity in a number of venues. The models predicting access to and use of ICT and possession of social capital act as sub-models and are treated as independent variables in the final model predicting gender differences and changes in productivity.

Dependent Variables

Research Output: Productivity

Much of the research concerning career differentials between male and female scientists attempts to explain disparities in career *outcomes* in terms of position, pay, and productivity. The present analysis of female scientists in Ghana, Kenya, and Kerala is concerned primarily with explaining differential outcomes in productivity. While the focus on productivity at the exclusion of position and pay is partly due to data constraints, I argue that productivity is also a more universal measure of a 'successful' research career.[23] It is, after all, through scientific productivity that researchers share their ideas with others, contribute in a highly visible way to the profession, and generate outside interests in their research as well as collegial recognition expressed through "citations to published work, material rewards such as research grants and the conferral of formal honors" (Reskin 1977: 493). Furthermore, productivity is, at least to an extent, linked to position and pay.

Two issues have to be dealt with when measuring gender differences in productivity: research output and exposure (Xie and Shauman 2003). Research output refers to a count of

---

marriage and family, education and training, location and context, role performance and cumulative advantage. Xie and Shaumann (2003) identify a similar set of factors.

[23] There are, of course, variations, as productivity in the form of published papers tends to hold more significance in academia than productivity in other research oriented occupations.

publications in various venues (refereed journals, books, etc…), while exposure refers to the time boundaries placed on the output measures. Measuring cumulative productivity (the number of publications over a researcher's career) tends to cause the gender disparities in publications to appear greater than when using measures of research output over a short interval. Xie and Shauman (2003) argue that short-term productivity measures are in fact more appropriate to the study of gender differences in productivity because 1) the trend of female participation in science is relatively recent, and 2) female researchers are more likely to take time off from research due to familial responsibilities.

I employ eight, *short-term,* continuous measures of research output, which can be broadly divided into three categories: 1) three indicators are related to publications in 'mainstream' venues i.e. journals or books; 2) three indicators are related to other types of written work published or unpublished, which may be considered outside of the mainstream but still an important measure of output, and 3) two indicators are related to attendance at conferences. Within the 'mainstream' category, I examine the number of papers published in foreign and domestic journals and the number of chapters published in edited volumes in the previous five years i.e. since 2000. The three variables within the second category include the number of reports—published or not—and the number of bulletins written for extension in the previous five years. I also examine the number of research papers written in the 12 months preceding the interview regardless of whether or not the papers were published. The final category measures the number of papers presented at local or national workshops as well as the number of papers presented at international conferences, again within the timeframe of the past five years. Although each of these areas of productivity is of interest, previous research has noted that the most significant distinction between male and female researcher's productivity levels emerges in

the comparison of foreign versus national journals and in the number of chapters male and female researchers publish in books (Campion and Shrum 2004; Miller et. al. 2006). As such, I am particularly interested in the gender differences over time for publications in these venues.

Professional Network Structure

Much of the literature on gender disparities in careers, whether scientific or otherwise, focuses on differences in professional and organizational contacts as a key factor in predicting disparities in outcomes. As such, I also examine changes and gender differences in researcher's professional network structure (Shrum and Bankston 1993/4; Shrum and Beggs 1996; Shrum and Mullins 1988). While I analyze both interorganizational and intraorganizational ties, the bulk of the network analysis stems from the information regarding the interorganizational contacts of researchers. Using an ego-centered approach to network analysis (in which data is gathered about the ties of a specific or focal actor to a set of alters) I examine the relationships between the respondents and other domestic or foreign **researchers**. In other words, I examine the ties between ego and his/her alters identified at the individual level.[24] The gender, geographic location, sector and means of contact for each alter was gathered (information on the gender of the contacts was only gathered for the second wave of the survey).

Among the more basic measures of network structure employed in social network analysis is network size and heterogeneity or diversity. I analyze the absolute size of the respondent's professional networks. Size can range from 0—no contacts—to 12. I also look at network size within the professional organization of ego. Respondents were asked to report the number of professional scientists and engineers, technicians and field workers, doctoral students,

[24] Information about these ties was gathered using a twelve person name generator. Respondents were asked to list individuals who they considered to be most important for their work, primarily people with whom they have similar professional interests or whose research activities were similar to their own. Individuals employed in the same organization or academic department as the respondents were excluded as contacts.

postgraduate students, and non-technical staff within their organization with whom they worked closely. Intraorganizational network size is based on the sum of these people.

I am also interested in examining the geographic location of alters based on 1) ties within the immediate location (TVM, Nairobi, Accra); 2) ties within the country but outside the immediate area (Kerala, Kenya, Ghana); 3) ties within the continent but outside the country (India outside Kerala/Africa outside Kenya, Ghana); and 4) ties at the scientific core (i.e. in Europe and the United States). I use this information to create an index of qualitative variation (IQV). IQV is a measure of the diversity of ego's professional ties based, in this instance, on the geographic locations of the alters and ranges from 0 to 1 (Hurlbert et. al. 2000; Marsden 1990). Finally, I use the information on geographic location to examine the proportion of professional ties within: 1) Kerala, Kenya, and Ghana including within the capital city (Trivandrum (TVM), Nairobi or Accra) but outside of ego's parent organization; 2) the continent but outside the country of the respondent (India outside Kerala or Africa outside Kenya and Ghana); and 3) the scientific core.

I also examine the gender composition of ego's professional networks. I examine gender diversity (ranging from 0 to 1) using the IQV measure discussed above in relation to geographic diversity. I also examine the proportion of contacts who are male. Finally, I am also interested in examining the way in which the contacts are maintained in terms of the technology used to contact one's professional ties. In the first and second waves of the survey, respondents were asked to report the means used to maintain contact for each tie (face-to-face, landline telephones, letters, email, and for the second wave, mobile phones). For each tie, a respondent could mention five means of contact in the first wave and six means of contact in the second. In other words, if I were analyzing the size of a respondents network based on the means of contact at

time two, the value could range from 1 (one contact, using one means) to 72 (12 contacts, using six means). However, because mobile phones were not included as a possible means of contact in wave one, I exclude it from the time two calculation in order to have a more accurate comparison of the two waves.

Independent Variables

Gender and Access to and Use of Technologies

The primary independent variable of interest for this study is gender (0 female, 1 male). However, I am also interested in examining the way in which technology mediates between gender and career outcomes in terms of professional network structure and productivity. Within the dimension measuring access to and use of ICT and other resources, there are four components that I examine: 1) access; 2) identification as a current user; 3) adoption; and 4) use. Consistent with previous literature in this area, I begin by focusing simply on gender differences and changes over time in *access* to various resources. To measure access, I employ two dichotomous variables where '1' indicates ready access and '0' indicates no access to personal computers (at work) and email. In the multivariate analysis, I examine *consistent* access to email and consistent access to a PC at work. In other words, I measure ready access to these technologies in both waves of the study (1=ready access to email or a pc in wave one and two; 0=other). To measure use, I employ two dummy variables assessing whether or not the respondents identify as current users of email and the web. But as with access, I am interested in the factors which predict consistent identification as a current user of the two technologies (1=current user of email or the web in both waves, 0=other).

To measure simple access to any of these technologies, while important, is incomplete. Of course, without access, one cannot use a technology, but access in and of itself does not

indicate diversity or intensity of use or the degree of experience a person has using a technology, all of which are necessary measures to provide a more nuanced picture of ICT diffusion. Diversity of use is a measure of the types of activities a person engages in while using email or the web. Some individuals may use these technologies to complete a number of daily activities from shopping and entertainment to maintaining personal and professional relationships while another person's use may be much more limited.

To measure diversity of Internet use, I employ two scales for email and web practice. Consistent with Ynalvez et. al. (2005) I employ an email diversity scale, or a measure of the extent of email use, which uses six dichotomous variables (1=yes; 0=no) measuring whether or not the researchers have: 1) been a member of a discussion group concerned with science and technology issues; 2) sent a message to a discussion group concerned with science and technology issues; 3) discussed research with someone in the United States, Europe or another developed country; 4) started a professional relationship with someone they met on the Internet; 5) discussed proposals with a funding agency; and 6) submitted or reviewed manuscripts for journals. Diversity can range from no diversity in use—a score of 0—to maximum diversity of use—a score of 6.

Web use diversity, or the extent of Web use, is measured by scaling thirteen dichotomous variables (1=yes; 0=no). They measure whether or not the respondents have: 1) ordered a product or service for their research; 2) created a web page; 3) conducted an information search; 4) used an electronic journal; 5) acquired or used data from the web; 6) collaborated on a scientific project; 7) found and examined reference materials; 8) accessed research reports or scientific papers; 9) participated in online chat groups; 10) used online job listings; 11) used online maps; 12) downloaded software; and 13) published a paper on the web. Web use

diversity can range from no diversity—again a score of 0—to maximum diversity—a score of 13.

The final two components of this dimension reflect the intensity and experience of Internet use. The intensity of Internet use is measured by examining the frequency with which respondents use email and the web. One ordinal variable is used to assess the frequency of email use and that is the number of hours in a typical week spent sending and receiving email messages (0=none, 1=low, 2=medium, 3=high number of hours) in the second wave of the study. Frequency of web use is measured using one ordinal variable assessing the number of hours in a typical week spent using the web (coded in the same manner as above). I also examine the intensity of PC use. Connected to the intensity of ICT use is the final component along this dimension which accesses the experience of respondents using personal computers, email and the web. Experience is measured by examining the number of years respondents have used the specific technology.

Control Variables

Family Structure and Demographics

To measure the second dimension identified as relevant to sustaining gender differences in the research career—family structure—three variables are used. The first variable is a dummy variable indicating the respondent's marital status (1=married; 0=not married). The second variable is a continuous measure of the respondent's number of children, regardless of age. And finally, the third measure of family structure is a dummy variable for the occupation of the respondent's spouse (1=researcher, 0=other). In chapter four, I also include a measure of spouse's occupation when the spouse stays at home and does not work in the paid labor force (1=stay at home spouse, 0=other). However, because none of the women reported a spouse who

did not work outside of the home, I exclude this measure from later analyses. In addition to family structure, I also control for the age of the respondents.

Human Capital

The third dimension of the research career identified as relevant to career outcomes is human capital. Human capital includes any measure of skill the respondent possess or training they may have undergone which might in some way contribute to positive career outcomes in the sense that they are identified as necessary or at the very least beneficial for career advancement in position and pay or for increased productivity. I use two dichotomous measures of human capital. The first assesses the percentage of males and females who possess the PhD (1=PhD holder, 0=non PhD holder) and the second assesses the percentage of males and females whose highest degree is the Master's (1=Master's degree holder, 0=non-Master's degree holder).

Contextual Factors

I employ two measures of context as control variables. These factors include the country in which the respondent is employed (Ghana, Kenya, or Kerala) and the sector in which they are employed (university or national research institute). In chapter four, I examine the bivariate relationship between the field of study (a nominal variable with five categories: 1=agriculture, 2=physical sciences, 3=biology/biotechnology, 4=information science/engineering/math-statistics and 5=social sciences) and gender. This factor is not included in the multivariate analysis, however, due to previous research in this area noting the relative lack of significance between field of study and measures of career outcomes.

Technological Antecedents

I employ two measures related broadly to ease of use of a technology and feelings of self efficacy. Ease of use and self-efficacy emerge as fairly consistent predictors of whether or not

and how much women use a technology. In chapter four, I examine the bivariate relationship between gender and the location of the workplace computer over both waves of the survey (1=PC in private office, 0=other/no work computer). Female researchers may not have ease of access to a computer, email, or the web at work due to issues of sharing and so may turn to the home computer in order to access and use these technologies. I also measure self-efficacy through a measure of comfort with the Internet. Comfort using the Internet ranges from never having used the Web (0) to very comfortable using the Web (4). In the multivariate analyses, however, I measure consistent access to a PC in one's office (1=PC in private office over *both* waves of the survey; 0=other/no work PC),[25] and I measure *increased comfort* using the Internet. Increased comfort is accessed by subtracting the respondent's time one value on the comfort measure from their time two value. A negative value on this measure thus indicates decreased comfort using the Internet, a value of 0 indicates no change in comfort, while a positive value indicates increased comfort using the Internet.

Localism

I examine the researcher's degree of localism by looking at the number of years spent outside of the country of origin for higher education & training. While female researchers in less developed areas consistently express a more local orientation and also tend to be less productive, the relationship between the two concepts has not been fully examined. Although I include a number of measures of localism in chapter four, I only employ the one continuous variable in the

[25] Other includes respondents who did not have a PC in their private office in the first wave but did in the second; those who did have a PC in their office in the first wave but did not in the second; and those who did not have a PC in their private office in either wave.

multivariate regression models predicting access to and use of ICT, network structure, and productivity.[26]

Methods for Analyzing Two Wave Panel Data

Broadly there are two components of change that I am interested in examining within the six dimensions. I examine both intra-group changes—those changes within female researcher's careers—as well as inter-group changes—comparing the changes in the careers of male and female researchers (Singer and Willett 2003). In order to do this, the first portion of each of the result chapters provides a series of tables measuring the bivariate relationship between gender, time and the relevant outcome variables. I examine any significant gender differences for the mean values of men and women at time one and then again at time two on those variables relevant to the issues being examined (i.e. access to resources, professional networks, etc…). Mean differences between males and females are tested using the independent samples t-tests and the F statistic (for those variables measured at the interval level) and the chi square test for significance (for variables measured at the nominal or ordinal level).

The second component compares the mean scores for women at time one to women at time two and men at time one to men at time two on those variables relevant to the issues being examined. For variables measured at the interval level, I employ a paired samples t-test, and for variables measured at the nominal or ordinal levels, I employ the McNemar symmetry chi-square test and an extension of the McNemar test, the marginal homogeneity test, respectively.[27]

[26]The other measures of localism include the percentage of respondents with any developed country educational experiences, the number of days away from parent organization, and the number of years spent abroad altogether in the developed countries.

[27] The McNemar test operates by testing whether those values above and below the diagonal of a square table are significantly different from one another. Stated differently, this statistic tests the assumption that the marginal frequencies are homogenous. If the McNemar Chi-Square is significant, one can reject the assumption that the frequencies are homogenous. In other words, that there has been no significant change over time. If they are significantly different from one another, this reflects a change between the two samples due to either an experimental effect or the passage of time (Allison 2005; Field 2005).

The final component comprising the first portion of each of the results chapters examines the mean change scores for men and women on those variables relevant to the issues being examined using an independent samples t-test and chi-square test.[28] In this way, I am able to examine significant gender differences at time one and two, as well as examine whether or not there have been any significant changes in the careers of female researchers as a group and in comparison to male researchers.

The second part of each chapter provides the predictive change models using multivariate analyses. In addition to the benefits of using panel data, such data also present a number of challenges. Each of the analytical methods used to examine panel data possesses certain strengths and weaknesses and there is not a great deal of consensus surrounding the analysis of panel data. Specifically there are five basic panel analysis models: 1) structural equation models with reciprocal and lagged effects, 2) repeated measures analysis of variance, 3) growth curve and hierarchical effects models, 4) fixed and random effects regression estimators and 5) regression using change scores (which includes lagged dependent variables, residual change score models, lagged panel models, and first difference models of change) (Johnson 1995: 1066).

Because the data used for this dissertation are from a two wave panel design, one would typically employ either a first difference design, also known as the unconditional change score model, in which the regressor variables and the dependent variable are a series of change scores. One could also use the static score, also known as the conditional change model, to model

[28] When examining the change scores (Xi2-Xi1) for males and females using dichotomous variables, the number of response categories defining the variables is four for both males and females. So, for instance, when measuring the change score on marital status at time one and marital status at time two (1=married; 0=not married), the new categories are defined by the percentage of males and females: 1) married in wave one but not married in wave two; 2) not married in wave one and not married in wave two; 3) married in wave one and married in wave two; and 4) not married in wave one but married in wave two.

changes over time. For a two wave panel design, the basic model for change scores is as follows:

$$\text{Model 1 } \Delta Y=\Delta\beta_0+ \beta_1\Delta X++\Delta\varepsilon$$

In this model, the value of the dependent variable at time one is subtracted from the value of the dependent variable at time two (Y_t-Y_{t-1}) and the value of the independent variables at time one is subtracted from the value of the independent variables at time two (X_t-X_{t-1}).

In the static score or conditional change design the model for change takes this form[29]:

$$\text{Model 2 } Y_t=\beta_0+ \beta_1X_t+\beta_2Y_{t-1}+\varepsilon_{t-1}$$

In this model, the time two dependent variable is regressed on the time one dependent variable and the time two independent variables. As in a cross-sectional regression model, β_0 is the value of the y intercept and β is the effect of the change in the independent variables on the change in the dependent variables and ε is the error term. This model can, of course, be expanded to include several independent variables and the coefficients estimated using OLS (Allison 2005; Finkel 1995; Johnson 1995). There are a number of variations on the lagged dependent variable model. Another option is to regress the time two dependent variable on its time one value and on the time one values of the other independent variables:

$$\text{Model 3 } Y_t=\beta_0+ \beta_1X_{t-1}+\beta_2Y_{t-1}+\varepsilon_{t-1}$$

In addition, one could also regress the time two value of the dependent variable on the time one dependent variable and a combination of time on independent variables and independent variable change scores.

$$\text{Model 4 } Y_t = \beta_0+ \beta_1\Delta X+ \beta_2Y_{t-1}+ \varepsilon_{t-1}$$

[29] In order for the model to be considered a Conditional Change Model, it simply needs to include the time one value of the dependent variable on the right side of the regression equation. The model can also predict a change in Y, using the time one value of the dependent and time one values of the independents. The model can also be specified

Choosing between these four models usually comes down to theoretical reasons rather than methodological ones. For instance, should it be assumed that the effect of the independent variable(s) on the dependent variable(s) occurs in a relatively short span of time or should one assume that the length of time required to notice the effect of the independent variable(s) on the dependent variable(s) is longer? If one assumes the former, model two is more appropriate as you are estimating the contemporaneous relationship between the predictor variables and the dependent variable. If one assumes the latter, however, than model three is more appropriate as it lags not just the dependent variable but the independent variables as well. Furthermore, one may predict that a change in some independent variable is theoretically linked to a time two value of an independent variable. If, for instance, one assumes that increasing travel outside of one's country leads to some effect on network structure, then the fourth model may be more appropriate.

There are advantages as well as disadvantages to each of these methods for predicting change. Use of the first difference or unconditional change score model under certain conditions is favored due to the fact that time-invariant but unmeasured variables are differenced out of the regression equation. In other words, in most sociological research, there are predictor variables that are both difficult to measure but important factors impacting the outcome of the dependent variable. If these variables do not change over time, using a first difference model of change essentially controls for their influence.[30]

---

to predict the time two value of the dependent variable using the time two values of the predictors or some variation thereof (Finkel 1995).

[30] Examples of time invariant measures abound. For instance, a nation's "location, topography, climate, rainfall, mineral resources, type and quality of soil, access to seaports, history, culture, economic system, political system, legal system, city system, religious composition, relationship with neighbors," organizational environment—including expectations for collaboration, productivity, resource availability—and field of study are all important but difficult to measure predictors for such things as network size and productivity in less developed areas (Firebaugh and Beck 1994: 636).

Although this model certainly produces stronger results than a cross-sectional design, there are a number of issues constraining the use of the unconditional change model. First, and perhaps most importantly, the model does not include the lagged dependent variable as a predictor of the time two outcome. This may be fine in certain situations, but when it is assumed that the time one value of the dependent variable has some causal relationship with the time two value of the dependent variable including the lagged dependent variable is appropriate (Allison 1990; Finkel 1995). Allison (1990) argues that the distinction between including the lagged dependent variable or not boils down to a difference between stocks and flows. Stocks are quantities that have an "inherent persistence" across time, while flows must be created anew in each time period or interval (107).

If, for instance, a model's dependent variable is productivity, one might assume that every time a researcher publishes an article, the likelihood that he/she will publish again increases, a hypothesis that was in fact tested by Allison, Long, and Krauze (1982). In fact, many of the theoretical discussions surrounding gender and science assume a model of accumulative advantage, a situation in which those people with larger numbers of publications, professional networks, and with better access to a variety of resources will continue to be advantaged in this way over time compared to their less advantaged counterparts. For the models of interest here, it can generally be predicted that the time one values on the productivity and network measures has some impact on the time two values for these measures. Furthermore, the very benefit of using the unconditional change score model (i.e. time invariant predictors need not be included because they are implicitly controlled for) is problematic if, as the case is here, one's primary interest is in predicting the relationship between such time-invariant predictors as gender, country of origin, and organizational context on a change in the research

career. Although the effect of these variables is controlled for, one is unable to directly comment on their statistical importance in the model.

Finally, I include the lagged dependent variable as a predictor as it helps to account for regression to the mean. This refers to the tendency for respondents with high or low values on a given variable to decrease or increase, respectively over time. Including the lagged dependent variable as a predictor frames the analysis in the following way: do the independent variables X influence the dependent variable Y_t or change in Y, for fixed levels of Y_{t-1} (Finkel 1995)? Although Allison (1990) and Firebaugh and Beck (1994) have demonstrated the usefulness of the unconditional first difference change score model, I argue that my data is more appropriate for the conditional change score. For these reasons, I employ a static score or conditional change equation in which Y_t or a change in Y is predicted using the lagged value Y_{t-1} and a series of X independent variables (X_{t-1}) as predictors (Crenshaw 1991; Lyson et. al. 2001).[31]

Two regressions are employed in order to examine the dimensions of the research career outline previously based on the level of measurement. For dependent variables measured at the interval level I employ an Ordinary Least Squares OLS model using some variant of the conditional change model. The majority of my OLS models are found in chapters six and seven in which I predict changes in respondents network size and publication counts. Because count variables tend to be highly skewed (indeed using the skewness values and standard errors confirmed that these variables were not normally distributed), my regression models use the logged values of these variables. When using the logged values of the dependent and

[31] The decision of whether to include Xt or Xt-1 is one of the more difficult decisions to make when using panel data. In general, if the time between the different waves of the survey is sufficient enough for the time one values of the independent variable to have an effect on the time two dependent variable than lagged Xt-1 variables are preferred. However, it is difficult to theoretically determine how much time is necessary for the lagged independent variables to have an impact on the time two dependent variables. If the independent variables are stable such as gender, then the choice of which to use is simple because the effect will be the same. However, with something like

independent variables with panel data, the change model is essentially a growth-rate model (Firebaugh and Beck 1994).

Variables measured at the nominal or ordinal level Binary Logistic equations are employed, again using some variant of the conditional change model. In chapters six and seven, I present three models for each dependent variable. The first model, presents the regression results for the full sample, while the second and third models disaggregate the results by gender. In this way, I am able to examine the differential effect of the independent variables on the dependent variables for men and women individually using the Proternoster Z score.

network sizes impact on productivity theoretical debates should inform the decision of which to use (Finkel 1995: 13).

CHAPTER 4: DEMOGRAPHIC AND BACKGROUND CHARACTERISTICS

Introduction and Review of the Literature

The bulk of the literature on women in science focuses on women in highly functioning scientific systems such as those found in the United States, Western Europe, and some Asian countries (Barber 1995; Cole 1979; Fox 1995; 1996; 1999; Kemelgor and 2001; Xie and Shauman 2003). The focus of these studies tends to be on 1) explaining the historical position of women in the research endeavor and 2) identifying the factors contributing to the unequal place of men and women in science. In the United States, over the last forty years the numbers of women entering graduate school in a scientific field and going on to have research careers has steadily increased, particularly within the life and social sciences and to a lesser degree in the physical sciences and engineering (Barber 1995; Burrelli 2008; Clewell and Campbell 2002; Cole and Zuckerman 1987).[32]

The fact that gender differences in promotion and pay have persisted in spite of increasing numbers of women entering scientific professions, has led many researchers to examine the source of these relatively stable differences (Leahey, 2006). While most of the gender disparities in academic rank and pay are largely attributable to a gender gap in productivity, explaining *why* women are less productive has produced less consistent results. The majority of this chapter focuses explicitly on identifying the gender disparities on those variables typically identified as important factors leading to differential career outcomes, both in terms of access to and use of resources, differences in the structure of professional contacts, and differences in productivity levels, for male and female researchers. A number of explanatory

[32] According to a report issued by the National Science Foundation, in 2006 the proportion of women earning a degree in a S/E field reached 40% compared to only 8% in 1958. Regardless of field, the proportion of women earning a degree has increased. However, there are significant differences by area of study: of all women earning a

variables, broadly related to individual and institutional factors, have been employed to explain gender disparities in career outcomes. Within the individual dimension, such factors as marital and parental status and age have been identified as predictors of career attainment (Fox 1995; Fox 1999; Kyvik and Teigen 1996; Long 1990; 1992; Sonnert, et. al. 2007; Xie and Shauman 2003).

According to this line of research, there is an age gap in both the use of new technologies and levels of productivity (Nie and Erbring 2000). Katz, Rice, and Aspden (2001) discovered that people over the age of 65 tend to use the Internet less often than other demographics, a fairly intuitive finding. It has also been found that younger users are likely to use such communication mediums as chat rooms or instant messaging at a greater rate than older people (Nie and Erbring 2000; Nie et. al. 2000; Howard, Rainie, & Jones 2002). Age also tends to be negatively associated with productivity, particularly for female researchers. Due in part to the fact that it is only within the past couple of decades that women have made significant advances in post secondary scientific education, these studies suggest not only do older women publish less than younger women, but they also publish less than men who are of a comparable age. These trends bare tracking as they may be a cohort effect rather than the effect of getting older. The effect of age on social networks for the general population also differs by age with ties to nonkin peaking in the early thirties and then declining (Fischer 1982; Fischer and Oliker 1983; Marsden 1987). Unlike the association between age and resource use and productivity, this relationship may not be a cohort but an actual age effect.

There is also a general consensus that female researchers postpone family formation at rates greater than their male counterparts (Burrelli 2008; Cole and Zuckerman 1987; Fox 2005;

---

doctoral degree 71% was in psychology, 52% in the life sciences, 30% in mathematics, 29% in the physical sciences, 21% in the computer sciences, and 20% in engineering (Burrelli 2008).

Xie and Shauman 2003).[33] Female researchers, in other words, are less likely than their male counterparts to "combine a family life with an active S/E [science and engineering] career" perhaps because of the conflict they feel between the two roles (Xie and Shauman 2003: 141). What are the consequences for the research career when men and women do decide to marry and form a family? The literature examining the relationship between family structure and career outcomes is both inconsistent and often counterintuitive.

A number of studies indicate that married researchers regardless of gender tend to be more productive than unmarried researchers. In regards to women specifically, this finding may be due in part to the tendency for female scientists to be married to other researchers, often within the same field (Astin and Davis 1985; Astin and Milem 1997; Cole and Zuckerman 1987; Creamer 1999; Fox 2005). Being married to another researcher provides female scientists with access to "mainstream networks of information, funding, and resources for research," hence selective mate selection may impact not only productivity but also professional network structure (Fox 2005; 141). If women are married to a researcher within their field they may collaborate with their husbands, and colleagues may feel more comfortable collaborating with a married woman. Even this positive relationship is more complex than it may initially appear. Fox (2005), for instance, found that being married to a researcher is only positively associated with productivity for women who are in a *subsequent* marriage. The effect of spousal occupation on productivity in first marriages, on the other hand, is stronger for female researcher's whose husband is in a nontraditional occupation or who is a scientist outside of academia.

The addition of children to the family has often been conceptualized as detrimental to women's careers, but the empirical findings often don't mesh with expectations. Mason and

[33] According to the 2008 NSF study noted above, 67% of female S&E faculty were married and only 42% of them had children compared to 84% and 50% respectively for males (Burrelli 2008).

Goulden (2004), for instance, argue that the impact of children on the research career depends, in part, on the moment at which a woman decides to have children. Examining the role of children in predicting academic rank, they found that women, who have children early in their careers, tend to choose or be forced by time and energy constraints into non-tenure track academic positions. In comparison, women who have children at a more advanced stage of their career tend not to display differential career outcomes in terms of tenure rates.

Others note either a slightly negative but insignificant effect (Reskin 1978; Long 1990), a non-effect (Cole and Zuckerman 1987; Fox 2005), or even a positive effect of the presence of children on career outcomes for female researchers (Astin and Davis 1985; Fox 2005; Fox and Faver 1985). The majority of these studies, however, focuses explicitly on productivity and do not examine issues related to professional network structure or access to resources. Studies done on the general population, find that family structure effects network composition. People with children tend to report fewer ties to non-kin, while married people have more ties to kin but smaller networks in general than do unmarried persons (Fischer 1982; Wellman 1985; Gerstel 1988; Hurlbert and Acock 1990). Anecdotal evidence also suggests that female researchers with children experience more time constraints than do their male counterparts and thus report feeling as if they do not have time for informal discussions with colleagues (Cole and Zuckerman 1987).

A number of studies have also demonstrated links between gendered uses of technology (such as personal computers, equipment, and even graduate students) and career outcomes (Mohsin 2000). According to Mohsin (2000), there are three factors influencing women's use of technology, including: 1) easy availability; 2) practicality; and 3) profitability. The first factor is of primary interest here. Within the literature, ease of use is generally used to mean "the degree to which a person believes that using a particular system would be free of effort" (Davis 1989:

320). Although the measure employed in the analyses to follow does not perfectly capture this facet of technology use, it does measure one aspect: respondents with a personal computer in their office are more likely to have unmediated access to the technology, while those without the technology in their office are more likely to have to share. A computer in one's private office is likely to lead to perceptions that the technology is more available for use.

A final aspect of the digital divide beginning to appear in the literature concerns the self-perceived competence of Internet users (Carnegie Mellon University 1997; Jackson et. al. 2001; Howard, Rainie, & Jones 2001; Cooper 2003). In this regard, a number of antecedents have been identified in discussions of the relationship between gender and the use of various technologies. These antecedents include motivational, affective, and cognitive factors. Motivational factors measure a person's reasons for using technology to begin with, whereas the affective and cognitive factors refer to the self-feeling one gets from using technologies and one's attitude and familiarity with technologies.[34] Social cognitive theories hold that self efficacy defined as one's "judgment of one's ability to use a technology to accomplish a particular job or task" is an important predictor of whether or not women use a technology (Venkatesh et. al. 2003: 432).

In a study examining the factors contributing to Internet use and activity, Jackson et. al. (2001) noted that affective factors such as level of comfort, skill, and anxiety each influence the extent of activities and the types of activities that an individual will engage in while online. Many of the early studies regarding women's affective and cognitive associations with technology suggest that women experience a greater degree of negative feelings towards technology and express less favorable attitudes towards computers and the Internet due in part to a feeling that they are not experienced enough with the technology (Jackson, et. al. 2001). Of

[34] For instance, people use the Internet to communicate with others, gather information, shop, be entertained, and as a venue for self-expression.

course, the relationship between self-efficacy and technology use is likely to be a circular one, but it seems reasonable to suggest that greater feelings of competence and comfort may lead a person to be an earlier adopter when compared to someone who does not see themselves as competent technology users, which only serves to reinforce the perception that one lacks the ability to use the technology in question.

Focusing on institutional factors contributing to differential career outcomes, organizational sector and field of study often emerge as important in the research career (Mahlck 2001; Sonnert et. al. 2007). Expectations for productivity, service, teaching responsibilities, and collaboration are to a degree dependent upon whether one is employed in a research institute or university and the nature of the field in which one works. Scientists in biology, chemistry, and physics, for instance, tend to work in laboratories with a number of other faculty members, graduate students, and post-doctoral researchers creating what amounts to a built-in collaborative environment. Scientists in sociology, psychology, and anthropology, on the other hand, are more likely to work with smaller groups or in isolation. Connected to the field environment, those in the hard sciences also tend to have higher publication counts due to the nature of the laboratory set-up. As noted above, within more developed areas, women are more likely to enter a S&E career in the social and life sciences, whereas men are more likely to enter a career in physics, engineering or math.

Organizational environment has also been noted to be a significant predictor of career outcomes (Allison and Long 1990; Nakhaie 2002; Fox 1991; Fox and Mohapatra 2007; Long and McGinnis 1981; Xie and Shauman 2003). Researchers working in universities face different expectations and environmental constraints than do researchers working in industry or government research institutes. Not only are university professors expected to teach in addition

to conducting research, they are also typically required to possess a PhD, and they are generally viewed as enjoying more freedom to select and conduct their research. More importantly for the purposes of this study, productivity in the form of publications is directly tied to promotion and salary for a university scientist.[35]

The experiences of women in less developed areas in both their careers and graduate school are likely to be similar if not exacerbated due to the fact that they live and work in countries and institutions often lacking in financial, technological, and infrastructural resources. Furthermore, women in India, Ghana, and Kenya face greater barriers to education and research careers due, in part, to more traditional gender roles marked largely by systems of patrifocality. Defined by Gupta and Sharma (2003), patrifocality refers to:

> "kinship and family structures and ideology that gives precedence to men over women, and includes the following: subordination of individual to family; patrilineal inheritance, patrilocal descent and residence that reinforce the centrality of males; gender-differentiated family roles (woman's nurturing and domestic roles versus man's economic roles); patriarchal authority structures; regulation of female behavior; marriage system, including dowry; and an ideology emphasizing women's chastity and subservience" (279-280). While it is generally acknowledged that female researchers in less developed countries fall behind their male counterparts on such dimensions as participation, productivity, position, and pay, little is known about the factors contributing to such outcomes (Amancio 2002; Gupta and Sharma 2002; Kumar 2001; Sharma 2004; Sharma 2004).

Among the limited number of studies conducted on science and gender in developing areas, the findings seem to indicate that the gender differences on those variables traditionally used to explain career attainment i.e. educational attainment, family structure, field of study, and involvement in outside organizations, are quite small (Campion and Shrum 2004; Kumar 2001).

[35] Other studies examine the prestige of both the PhD granting institution and the institution where women are employed, noting a tendency for female researchers to have graduated from and to be employed at institutions with fewer resources and fewer prospects for promotion (Allison et. al. 1982; Fox 1995; Fox 1999; Long 1990). Furthermore, they note that the pool of other female faculty members available for mentorship and guidance is much smaller in comparison to what is available for men. Over time, the initially small disadvantages women face in such institutions accumulate, resulting in large gender differences later in the career.

Over time, furthermore, these differences appear to be diminishing. Miller et. al. (2006) using longitudinal data gathered on researchers in Ghana, Kenya, and Kerala, India over two time periods, found that in the first time period (1994) women were significantly less likely to possess the PhD than their male counterparts but in the second time periods (2000-2002), women were equally likely to possess the PhD indicating that for those women choosing to pursue a career in science, they are closing the gap in human capital.

While very few significant gender differences emerge on most traditional measures, there is one exception. Female researchers tend to display a more local orientation to their careers, defined primarily in terms of travel experiences but also including publication venues and professional network structure (Palackal et. al. 2006; Campion and Shrum 2004; Miller et. al. 2006). Female researcher's careers lag behind their male counterparts on a number of dimensions broadly related to localism including: the size of their non-domestic professional networks (women report consistently larger domestic but smaller foreign ties), and their productivity in foreign journals (women publish less in foreign journals).

In relationship to resources, even fewer studies have been conducted on female researcher's access to ICTs in less developed areas. The research that has been done, while not necessarily taking an explicit focus on gender, suggests that the impact of the Internet in developing areas is not a simple issue of connectivity. Instead, Ynalvez et. al. (2005) and Ehikhamenor (2003) both found that Internet access and use varies by region, organization of employment, and personal and professional dimensions (Ynalvez et. al. 2005).

Between Group Differences—Independent Samples Test

This chapter presents a series of t-tests and crosstabs with gender as the primary independent variable. I examine the gender differences over time on those dimensions assumed to be

significant predictors of career outcomes: familial structure (i.e. marital status, parenthood, spousal occupation), possession of human capital in the form of an advanced degree, contextual factors (i.e. country of employment, organizational sector, and field of study), and technological antecedents related to ease of use and cognitive factors related to comfort of use.

Table 4.1 presents the crosstabs measuring the research context within which the respondents are employed. Intuitively, the distribution of researchers based on country, research sector, and field should not change dramatically from one wave of the survey to the next. Indeed, with a few exceptions, this is precisely what emerges.[36] The majority of female researchers in both waves are working in Kerala (58% compared to 27.3% of men). This is consistent with the historical and cultural gender circumstances present within the state. The distribution of male researchers by country is more evenly divided, with the majority working in Kenya (38.5% compared to 29.4% of women).

According to table 4.1, women in both waves are far more likely to be employed in academic institutions than in the research sector (66.4% in academic institutions compared to 33.6 in research institutes). While the majority of men are working within agriculture (27.6%), the distribution across fields is relatively even for males as a group (with the exception of the social sciences). Women, on the other hand, are concentrated in a biology or biotechnology field. Consistent with trends in the United States, nearly half (approximately 44%) of all women in both waves of the study are working in this area. They are least likely to be working in an IT, engineering, mathematics, or physical science field (approximately 7% and 11% respectively).

[36] The five category variable measuring field does present some discrepancies between survey years. In most instances, the discrepancies appear to be caused by a genuine change in degree. In other words, a respondent changes field of study between his/her masters (acquired prior to the 2000-2002 study) and his/her PhD (acquired after the first wave of the study but before the second). In total, nine respondents report discrepant field categories between waves of the survey.

Table 4.1: Chi-Square test of Contextual Differences Between Male and Female Scientists in Wave One and Wave Two: Country, Organization Type, and Field Differences

	2000-2002[1]			2005		
Variable	Male	Female	N	Male	Female	N
Context						
1. %Country	***		540	***		540
Ghana	34.2	12.6		34.2	12.6	
Kenya	38.5	29.4		38.5	29.4	
Kerala	27.3	58.0		27.3	58.0	
2. %Organization Type	**		540	**		540
Academic	52.0	66.4		52.0	66.4	
Research Institute	48.0	33.6		48.0	33.6	
3. %Field	***		539	***		539
Agriculture	27.6	27.1		27.1	26.3	
Physical Sciences	20.9	11.0		20.9	11.0	
Biology/Biotech	26.8	43.2		27.6	44.1	
IT/Engineering/Math	21.1	6.8		20.2	6.8	
Social Sciences	3.6	11.9		4.3	11.9	

[1] ***p<.001; **p<.01; *p<.05

In table 4.2, I present the chi-square tests and independent samples T-tests for gender differences in wave one and wave two on age, familial structure, human capital, technological antecedents, and localism. Women are significantly younger than their male counterparts by approximately two years. Consistent with the extant literature on female researchers in more developed areas, women in Ghana, Kenya, and Kerala are significantly less likely in both waves of the survey to be married (84.9% in wave one compared to 93.3% for males and 85.7% in wave two compared to 96.7% for males) and they have significantly fewer children than male scientists in both waves of the study (2.05 children in wave one compared to 2.42 for males and 2.10 children in wave two compared 2.61 for males).

This finding suggests that, like women in core scientific institutions, female researchers in the periphery postpone family formation more frequently than do male researchers. Women may perceive the presence of children and a husband to be deleterious to their research, inhibiting their ability to focus on their careers hence providing more motivation for them to postpone family formation and to have fewer children. On the one hand, if being married and

having children is indeed positively related to productivity levels—as it is in more developed areas—postponing family formation may actually negatively impact women's careers. On the other hand, while gender roles in more developed areas may be shifting creating more opportunities for men to adopt the caregiver role and women the breadwinner role, corresponding changes in Ghana, Kenya, and Kerala are not occurring at the same pace. Hence, the relationship between family formation and career outcomes may indeed be in the opposite direction from what is found in the United States.

Table 4.2: Independent Samples T-test and Chi-Square Test of Differences Between Male and Female Scientists in Wave One and Wave Two: Age, Family Structure, Human Capital, and Localism Differences

	2000-2002			2005		
Variable	Male	Female	N	Male	Female	N
1. Age	45.09**	42.85	540	48.70*	46.97	540
Family Structure						
2. %Married	93.3**	84.9	540	96.7***	85.7	538
3. #Children	2.42**	2.05	535	2.61***	2.10	533
4. %Domestic Laborer	18.1***	---	540	19.4***	---	536
5. %Researcher	9.6**	20.2	535	7.7**	16.8	536
Human Capital						
6. %PhD	55.3	56.3	540	60.3	66.4	540
7. %Masters	35.4	34.5	540	34.4	27.7	540
Technological Antecedents						
8. PC located in office	35.4***	16.8	534	67.1***	39.0	538
9. Comfort using the Internet	1.05*	.81	501	3.40	3.30	531
Localism						
10. %Any DC Education[a]	64.4***	28.6	508	73.6***	37.5	536
11. #Yrs outside country for ed.	2.23***	.95	529	2.52***	1.11	536
12. #Yrs spent abroad altogether	2.48***	1.14	532	2.77***	1.41	539
13. #Days away from parent org.	36.15**	22.16	496	35.65	34.10	519

***p<.001; **p<.01; *p<.05

Turning to spouse's occupation provides preliminary support for this argument. Close to twenty percent of male researchers (18.1 and 19.4) in both waves of the survey report having a spouse whose primary occupation is that of a domestic laborer. None of the women's spouses stay at home. A spouse at home alleviates domestic responsibility for male researchers, perhaps providing them with the freedom to work longer hours collaborating and publishing, and they

may also be able to spend more time traveling to conferences and training workshops outside of the local area. Approximately the same percentage of women report being married to a spouse who is also a researcher (approximately 20% in wave one and 17% in wave two). Again, these results closely model the findings coming out of more developed research systems.

While women represent a minority of the sample (and a minority of all researchers in Ghana, Kenya, and Kerala), the women who make it through the scientific 'pipeline' and are employed in a scientific career are actually slightly more likely to possess the PhD in both waves (56% of women compared to 55% of men in wave one and 66% of women and 60% of men in wave two). Although the results are not significant in either wave, it appears that by wave two, female researchers are creating a larger gap between themselves and male scientists in their possession of the PhD. Of course, the reverse is that as more women invest time in attaining a PhD, fewer are reporting the masters as their highest degree (34.5% compared to 35.4% in wave one and 27.7% compared to 34.4% in wave two).

Perhaps because this is a relatively unique sample or perhaps because the Internet has been around for a number of years, women are not dramatically less comfortable using the technology. Although small differences emerge in wave one, with women being less comfortable (.81 compared to 1.05 for men), these differences disappear by wave two (3.30 compared to 3.40 for men). However, in terms of the other antecedent factor identified as an important predictor of women's adoption of technology, ease of access, large gender differences emerge. In both waves, women are significantly less likely to have a personal computer in their office (16.8% of women in wave one compared to 35.4% of men and 39% of women in wave two compared to 67.1% of men).

Finally, table 4.2 presents the geographic orientation of the researchers. Female researchers in both waves of the study spend significantly fewer years outside of their respective countries either for educational purposes (.95 years in wave one and 1.11 years in wave two for women, compared to 2.23 and 2.52 years respectively for men) or for more general reasons (1.14 years in wave one and 1.41 years in wave two for women compared to 2.48 and 2.77 years respectively for men). These differences are reflected in the fact that women are also significantly less likely to possess a degree from a developed country (28.6% report this status in wave one compared to 37.5% in wave two, while 64.4% of men report this status in wave one and 73.6% report the same status in wave two).

On the majority of the variables measured, then, female researchers are indeed more local than their male counterparts regardless of the time period. The number of days spent away from the parent organization, however, emerges as a possible exception to this rule. In wave one, female researchers spend a significantly fewer number of days away from their organization compared to men (22.16 days compared to 36.15 days). By wave two, male and female researchers spend nearly the same number of days away from their parent organization (approximately 34 days for women and 36 days for men). While certainly displaying a greater degree of localism than their male counterparts, it is not the case that female researchers simply do not travel. Instead, their travel is of a different variety. They are consistently traveling less internationally then male scientists, but they are, at the very least, increasing their domestic travel for professional reasons. Based on Schott's concentric circles of scientific engagement, it would appear that women's travel experiences are exposing them more to the national circle of researchers as opposed to the more global circle of scientists, but this does not indicate that they are simply disengaged from scientific activity.

Within Group Changes: Dependent Samples Test

Tables 4.1 and 4.2 display the between group differences over time. However, they do not indicate whether or not there have been any significant within group changes. In other words, they provide data related to gender differences within each time period, but these results do not demonstrate whether or not women as a group have experienced any significant changes in their possession of human capital, expression of localism, technological access or perceptions or familial structure. Tables 4.3-4.3.1 present the results from a paired samples t-test and the McNemar Symmetry Chi-Square test.

According to table 4.3 both male and female researchers are significantly older over time by an average of four years (43 years in time one compared to 47 years in time two for women and 45 years in time one compared to 49 years in time two for men). In terms of family structure, regardless of gender, the respondents are having significantly more children over time (2.02 and 2.121 for women in times one and two compared to 2.42 and 2.617 children for men in times one and two).

Table 4.3: Paired Samples T-test of Differences Between Male and Female Scientists in Wave One and Wave Two: Age, Family Structure, and Localism

	Female			Male		
Variable	00-02	2005	N	00-02	2005	N
1. Age	42.849***	46.966	119	45.086***	48.698	421
Family Structure						
2. #Children	2.02*	2.121	116	2.42***	2.617	412
Technological Antecedents						
3. Comfort using the Internet	.82***	3.31	109	1.06***	3.38	384
Localism						
4. #Yrs outside country for ed.	.951**	1.102	117	2.246***	2.558	408
5. #Yrs spent abroad altogether	1.141***	1.408	116	2.490***	2.795	415
6. #Days away from parent org.	22.56	34.38	108	36.72	35.77	372

***p<.001; **p<.01; *p<.05

Turning to table 4.3.1, I examine the within group changes on the nominal variables measuring family structure using the McNemar's test. The McNemar Chi Square statistic tests the null hypothesis that the probability of shifting from being married to not being married over

Table 4.3.1: The McNemar Symmetry Chi Square Test for Change in Family Structure and Human Capital by Gender

Family Structure	
1. Marital Status	
Males (N=419)**	
Not married to married	4.8% (20)
Married to not married	1.4% (6)
Married to married	91.9% (385)
Not married to not married	1.9% (8)
Females (N=119)	
Not married to married	4.2% (5)
Married to not married	3.4% (4)
Married to married	81.5% (97)
Not married to not married	10.9% (13)
2. Occupation of Spouse: Researcher	
Males (N=413)	
Not researcher to researcher	3.1% (13)
Researcher to not researcher	4.8% (20)
Researcher to researcher	4.6% (19)
Not researcher to not researcher	87.4% (361)
Females (N=119)	
Not researcher to researcher	3.4% (4)
Researcher to not researcher	6.7% (8)
Researcher to researcher	13.4% (16)
Not researcher to not researcher	76.5% (91)
3. Occupation of Spouse: Domestic Laborer-DL	
Males (N=417)	
Not DL to DL	5.0% (21)
DL to not DL	3.8% (16)
DL to DL	14.4% (60)
Not DL to not DL	76.7% (320)
Females (N=119)	
Not DL to not DL	100% (119)
4. Human Capital: PhD	
Males (N=421)***	
No PhD to PhD	5.0% (21)
No PhD to no PhD	39.7% (167)
PhD to PhD	55.3% (233)
Females (N=119)	
No PhD to PhD	10.1% (12)
No PhD to no PhD	33.6% (40)
PhD to PhD	56.3% (67)
5. Human Capital: Masters	
Males (N=421)	
No masters to masters	4.5% (19)
Masters to no masters	5.5% (23)
No masters to no masters	60.1% (253)
Masters to masters	29.9% (126)
Females (N=119)	
No masters to masters	3.4% (4)
Masters to no masters	10.1% (12)
No masters to no masters	62.2% (74)
Masters to masters	24.4% (29)
6. Any DC educational experiences	
Males (N=392)***	
No DC education to DC education	8.7% (34)
No DC education to no DC education	26.3% (103)
DC education to DC education	65.1% (255)
Females (N=112)**	
No DC education to DC education	7.1% (8)
No DC education to no DC education	64.3% (72)
DC education to DC education	28.6% (32)
7. Location of Personal Computer (PC)	
Males (N=414)***	
No PC in office to PC in office	38.6% (160)
PC in office to no PC in office	6.5% (27)
No PC in office to no PC in office	25.8% (107)
PC in office to PC in office	29.0% (120)
Females (N=118)***	
No PC in office to PC in office	25.4% (30)
PC in office to no PC in office	3.4% (4)
No PC in office to no PC in office	57.6% (68)
PC in office to PC in office	13.6% (16)

***p<.001; **p<.01; *p<.05

the two waves of the study, for instance, is equal to the probability of shifting from not being married to being married over the same time period. In other words, it tests whether or not women as a group are more likely to experience one kind of change or another and vice-versa for men. Only male researchers are reporting a significant change in their marital status. They are more likely to be married over time. According to table 4.3.1 approximately 4.8% of male scientists have shifted marital status. Perhaps unsurprisingly, neither male nor female researchers are reporting a significant change in the occupations of their spouses.

Above, I noted that male and female researchers are approximately equivalent in terms of their educational attainment measured in the form of a PhD. Within group changes suggest that male researchers are experiencing a greater level of change over time on this measure as significantly more male researchers have acquired the PhD by wave two of the study (5%). There is no evidence of a significant shift in the highest degree at the Masters level for either males or females. As the results above suggested, both male and female researchers are significantly less locally oriented over time (rows 4 and 5). Although female researchers are more locally oriented than their male counterparts on nearly all of the measures of this dimension (and over both waves), it is not the case that they have not undergone any change on these measures. Men and women both are less locally oriented over time in terms of the number of years outside of the country for higher education (.951 years in wave one for women and 1.102 years in wave two, compared to 2.246 years and 2.558 years respectively for men), the number of years spent outside of the country for general purposes (1.141 years in wave one for women and 1.408 years in wave two, compared to 2.490 years and 2.795 years respectively for men), and in terms of the percentage reporting any educational experiences in a developed country (8.7% of men shifted on this measures compared to 7.1% of women). Interestingly, the increase

in travel away from the parent organization noted above does not translate into a significant shift for female researchers as a group.

Finally, both men and women are reporting shifts in the technological antecedent measures. In wave one, for instance, women's score on the comfort with Internet measure (out of a total possible comfort score of 4) was .82 compared to a score of 3.31 in wave two. In comparison, men's score in wave one was 1.06 compared to 3.38 in wave two. Over time, both men and women are becoming more comfortable with the Internet, which likely has to do with more experience using the technology. In addition, regardless of gender, researchers in these locations are more likely to have a personal computer in their office by wave two. 38.6% of men and 25.4% of women did not have a personal computer in their office in the first wave of the study but did by the second wave. As a point of comparison, only 6.5% of men and 3.4% of women actually lost access to a PC in their office over the two waves. It is important to note, however, that the majority of women are reporting no access in both waves (57.6%), while the majority of men (29%) are reporting access in both waves.

Summary

This chapter addressed gender differences and changes over time on the control variables described in chapter three. The gender disparities are consistent with the literature based on researchers in more developed areas. In terms of field of study, family structure, and human capital, the differences between men and women in Ghana, Kenya, and Kerala closely match those differences found between men and women in the United States and Western Europe, suggesting that within science, there is something that transcends context. In spite of different historical circumstances, socialization processes, and political and educational systems, the experiences of women in less developed countries closely match the experiences of their

counterparts in more highly functioning systems. While gender differences in localism and technology antecedents are not typically examined in the research systems of more developed areas, within LDCs they have been identified as important predictors of career outcomes. Outside of feelings of self-efficacy—measured through comfort of Internet use—and domestic travel away from the parent organization, men and women are quite different on these dimensions. Women are more locally oriented than men and their access to the technological hardware is more likely to be mediated through sharing with colleagues. The next question to be examined, then, is after controlling for the gender differences in family structure, human capital, contextual factors, and technological antecedents does gender emerge as a significant predictor of access to and use of personal computers, email, and the Internet?

CHAPTER 5: ACCESS TO AND USE OF TECHNOLOGIES

Introduction and Review of the Literature

The digital divide (discussed above) refers to a number of phenomena. Within the development literature, the term describes the disparity between rich and poor countries in access to and use of ICTs. The digital divide also refers to within country divisions which have historically been stratified along gender, race, class, and geographic i.e. rural vs. urban, lines. There are three areas of contention surrounding the digital divide and the diffusion of ICTs (Katz and Rice 2002). Broadly, they relate to access, involvement, and interaction. This chapter addresses issues related to access by examining the following question: what are the antecedents of ICT access and use? Specifically, in what ways does gender structure men's and women's access to and use of personal computers, the web, and email?

Katz and Rice (2002) based their assessment of the three debates surrounding ICT diffusion on data gathered in the United States between 1995 and 2000. At the time, penetration and use of the Internet were relatively low because diffusion of the technology was still occurring. As such, most research conducted on the consequences of ICTs examined issues related to adoption of new technologies along a simple dichotomy of access vs. non-access, adopters (early and late) vs. non-adopters. Based on this characterization of the spread of the Internet, Katz and Rice's findings as well as research produced by the Pew Internet and American Life project indicated that, while closing, there existed a persistent gender gap in online participation.

Approximately ten years later, the situation in terms of diffusion is dramatically different, not only in the United States but in Europe, Africa, and Asia as well. Access to ICTs has increased dramatically regardless of geographic location. Although the most significant gains

have been made in highly industrialized countries, there have also been significant increases in less developed areas as well. According to the 2007 UNCTD report issued on the state of technology diffusion in less developed areas, in 2002 Internet penetration in more economically developed areas was *ten* times higher than in less developed areas. By 2006, Internet penetration was only six times higher in more developed areas. Furthermore, within the United States, the gender gap in access and use has largely disappeared. Men and women, in other words, have approximately equal access to the Internet and both are equally likely to identify as users of the technology.

Given the extent of Internet diffusion, measuring access, while still important, particularly within a developing world context, is no longer sufficient in and of itself for assessing the digital divide (Brown 2008). Although disparities on this measure certainly remain, to adequately address the nature of the digital divide in the research systems of less developed areas, one must also assess issues related to type of use and technology experience (Ynalvez et. al. 2005). However, within this relatively optimistic assessment of technology diffusion hides a much more complex picture of the situation. There continue to be significant gaps in technology penetration both between countries as well as within.[37] A number of empirical studies, furthermore, demonstrate not only that the extent to which people report having access to the Internet-whether at home, work, or a more public setting such as a café or library-is increasing dramatically but the lauded benefits provided by the use of the Internet are not increasing with level of access (Attewell 2001; Bimber 2000; Natriello 2001).

[37] In fact, by breaking the UNCTD figures down into the number of users per 100 people this become more apparent. Between 2002 and 2006, the number of Internet users per 100 people increased from 42 to 58 in more developed economies and from 4 to 10 people in less developed areas (UNCTD 2007). Internet penetration has improved but marked differences between rich and poor countries remain.

To determine the dynamics behind these findings, the digital divide argument must be extended to include examinations into "the nature of online activities" (Miyata 2002:521). The underlying assumption behind this statement is that the Internet user who accesses the Internet primarily for email acquires distinctly different benefits then the user who accesses the Internet primarily for research. The same could be said of the Internet user who accesses the Internet multiple times a day, everyday for thirty minute intervals compared to the user who accesses the Internet once a day for fifteen minutes. In other words, it is the nature of online activity that predicts whether or not an individual actually accrues the benefits computer technologies have the potential to provide. As such, I delineate the predictors of ICT access in terms of who has access and who does not. Related to this, I also examine the factors predicting early adoption of ICTs. More importantly, I examine ICT behaviors which include the intensity and extent of ICT use.

Adopters of new technologies tend to possess certain characteristics distinct from non-adopters or late adopters. Women as a group tend to be later adopters of most technologies and they tend to use it for distinctly different purposes. As stated previously, there is a general consensus that the gendered digital divide in the United States has essentially disappeared. The differences between males and females in access to and use of the Internet are minimal. Within Internet activities, however, disparities continue to exist particularly when the findings are analyzed in terms of frequency and variety of activities, as well as perceived Internet and computer skill.

Howard, Rainie, and Jones (2002) and Boneva and Kraut (2003), for instance, found that men are more likely than women to use the Internet as an "information utility;" researching or reading the news, whereas women are more likely to use the Internet as a communication tool

(Boneva & Kraut 2003: 51). Ford and Miller (1996) also commented on what appears to be a divide in searching as compared to communicating between men and women. In fact, while not unequivocal, many of the available studies suggest that women are more frequent users of email, and they tend to use the Internet to maintain personal relationships with family and friends (Boneva, Kraut, & Frohlich 2001; Boneva & Kraut 2002). In addition, the Pew Internet study based in the United States finds that not only does a gender gap in *activities* exist, but the amount of time men and women spend engaging in different activities also differs. Males spend more time online engaging in a wider variety of activities than do females.

The studies described above are illustrative in that they point to potential gender differences, but there are a number of problems with much of the data that are available. First, these studies are old. Technology is changing all the time and rapidly. Six years ago males and females had distinctly different patterns of use but does the situation remain the same today? Second, very few studies have been done on the way in which female *researchers* use technology, particularly female researchers in less developed areas. The numbers coming out of the World Bank and United Nations tend to refer to Internet diffusion and access for the entire population. Researchers are a unique sample of this population who are not only more educated but are also likely to possess distinctly different patterns of resource access and use. As such, the statistics being reported by the UN and World Bank may not be generalizable to female researchers. Does the within country digital divide noted by these organizations persist within scientific institutions?

Among the limited number of studies available, the evidence suggests relatively limited gender differences in technology use. Measured in terms of simple access to email, Miller et. al. (2006), found that male and female researchers have essentially equal access. However, in terms

of the way in which developing world women are using technology in their research careers, the evidence is contradictory. Palackal et. al. (2006), for instance, using qualitative interviews with female scientists in India found that email was being used to develop a larger number of contacts outside of the immediate area. Miller et. al. (2006), on the other hand, discovered that researchers in Ghana, Kenya, and India, reported increased access to email between 1994 and the 2000-2002, but the greater access was not associated with increased international contacts. Instead, they actually reported a decrease. Although these results are more relevant for the next chapter on professional networks, they do suggest the possibility that female researchers in developing areas may not be using email for specific types of communication purposes.

Hypotheses

Based on the available evidence, I propose ten hypotheses related to gender and ICT access and use.

ICT Access

H1: After controlling for other factors, male researchers will be more likely to report consistent, long-term access to a personal computer than females.

H2: After controlling for other factors, male researchers will be more likely to report consistent, long-term email access than females.

Identification as an ICT User

H3: After controlling for other factors, male researchers will be more likely to report consistent, long-term Web use than females.

H4: After controlling for other factors, male researchers will be more likely to identify as long-term users of email than females.

Patterns of ICT Adoption

H5: After controlling for other factors, male researchers will be earlier adopters of the Web than females.

H6: After controlling for other factors, male researchers will be earlier adopters of email than females.

Patterns of ICT Use

H7: After controlling for other factors, male researchers will use the Web more intensely than females.

H8: After controlling for other factors, male researchers will use email more intensely than females.

H9: After controlling for other factors, male researchers will use the Web more extensively than females.

H10: After controlling for other factors, male researchers will use email more extensively than females.

Between Group Differences—Independent Samples T-Test

The first question I examine relates simply to gender differences across waves: is there a gender disparity in access, use, and experience with personal computers, the Web, and email, and if so, is the nature of the relationship between gender and these resources changing over time? Tables 5.1, 5.2., and 5.2.1 present the results of chi-square and t-tests measuring the gender differences on various dimensions of resource access and use. Regardless of the resource examined, a general pattern of improved access and increased activities emerges. Having said that, it also appears that from time one to time two there have been few shifts in the *gender differences* in access to and use of ICTs. There are only two measures for which gender

Table 5.1: Independent Samples T-Test and Chi-Square test of Gender Differences in Access to and use of Personal Computers, the Web, and Email in Wave One and Wave Two

	2000-2002			2005		
Variable[2]	Male[1]	Female	N	Male	Female	N
Personal Computers						
1. %Ready access to PC at work	76.0	81.5	540	94.5	94.1	540
2. Intensity of PC use	2.81*	2.46	528	3.19***	2.65	532
Web						
3. % Ever used web	70.7	61.3	536	93.3	88.1	535
4. # of years using Web	2.49***	1.50	527	5.93*	5.03	535
5. Extent of Web use	4.42**	3.30	512	7.12***	5.98	525
6. Intensity of Web use	1.16	.97	525	2.02*	1.73	525
Email						
7. %Ready access to email	67.2	67.5	532	92.6***	82.4	538
8. %Currently using email	90.5***	69.7	539	95.2	90.8	539
9. # of years using email	3.82***	2.39	534	7.16***	5.81	537
10. Extent of email use	2.35**	1.81	522	3.04**	2.54	532
11. Intensity of email use	1.55***	1.09	528	1.96***	1.65	525

[1] ***p<.001; **p<.01; *p<.05

[2] Variables proceeded by a % were measured at the nominal or ordinal level and the results are from a chi-square test. All other variables were measured at the interval level, and the results are from a t-test.

disparities do not exist over time. In general, gender differences remain in both waves of the study, with a few exceptions primarily related to issues of access and identification as users.

Regardless of wave, men and women report similar levels of access to personal computers at work (row 1). While approximately 79% of men and women report access to a PC in the workplace at time one, by time two, close to 95% of the sample, regardless of gender, reports having access to a PC in the workplace. In other words, there has been a dramatic increase in technological capacity within the work context. The true power behind the digital divide argument, however, is not in terms of access to the hardware but instead lies in connectivity—specifically Web and email access and use. The percentage of men and women reporting use of the web is approximately equal in both waves (row 3). Although men and women also report similar patterns of access to email in wave one, by wave two women report less access to the technology (67.2% of men report such access in wave one compared to 67.5% of women, and by wave two the corresponding figures are 92.6% and 82.4% respectively).

It is important to note, though, that regardless of gender, researchers in these three areas are reporting dramatic increases in access. A reverse trend in gender disparities emerges for

those researchers who identify as current users of email. In wave one, approximately twenty percent fewer women than men identify as current users (69.7% compared to 90.5%), but by wave two, the gender differences have essentially disappeared (95.2% of men compared to 90.8% of women identify as current users). Gender differences in access over time, in other words, are not translating into gender disparities in self-identification as an email user.

The other gender differences that emerge are consistent with the extant studies on the general population of the United States. Without controlling for other factors, males are earlier adopters of technology, they use them more intensely, and they use them for a wider variety of reasons in both waves of the study. Men, for instance, report using the web approximately a year longer than women (2.49 years in wave one compared to 1.50 years for women and 5.93 years in wave two compared to 5.03 years for women), and they report using email for approximately a year and a half longer than women (3.82 years in wave one compared to 2.39 years for women and 7.16 years in wave two compared to 5.81 years for women).

Men in both waves also do a wider variety of activities online and while using email. Their web use diversity in wave one is 4.42 out of a maximum possible diversity score of 13, while women's web use diversity score is only 3.30. By wave two men's web use diversity score is 7.12 compared to 5.98 for women. In other words, men are consistently engaged in more online activities than women. The same general finding emerges in regard to the gender differences in email activities. Men in both waves of the study engage in more email activities than women. Out of a possible score of six—one being the least amount of email activity, six being the most—men have a score of 2.35 on email use diversity in wave one compared to 1.81 for women. In wave two, they have a score of 3.04 on email use diversity compared to 2.54 for women.

Men also use the web and email more intensely in terms of the amount of time they spend online and using email. Interestingly, although male researcher's intensity of web use is not significantly different from women's in wave one it becomes so in wave two (1.16 for men in wave one compared to .97 for women and 2.02 for men in wave two compared to 1.73 for women). The gender differences in terms of the intensity of email use remains consistent across both waves with men using email more intensely than women (1.55 for men compared to 1.09 for women in wave one and 1.96 for men compared to 1.65 for women in wave two). Based on these results, it appears that the gender differences on most of the technological outcomes are consistent across waves. In other words, without controlling for other factors, men consistently outpace women in their technological behavior. However, the question that still remains is, are men becoming more technologically oriented over time while women are remaining stationary, or is it that men and women are both becoming more technologically oriented and skilled over time, but men are simply earlier technology users?

Within Group Changes—Dependent Samples Test

In tables 5.2. and 5.2.1, I examine the differences over time within groups. Table 5.2. examines those variables measured at the nominal level including: the changes in access to email and personal computers and changes in those who identify as current users of email. To test for significant, within group shifts on these measures, I employ the McNemar test. As stated in chapter four, the McNemar test essentially addresses the following question: Is the probability of shifting from 'X' status to 'Y' status equal to the probability of shifting from 'Y' status to 'X' status for men as a group and for women as group across the two waves of the study?

Using McNemar's test, a significant change was found for both males and females on their personal computer and email access and self-identification as email and Web users.

Table 5.2:The McNemar Chi-Square Test: Wave One to Wave Two Changes in Access to and Use of Email and Personal Computers

Personal Computer Measures	
1. %Ready Access to Personal Computer at Work:	
Males (N=421)***	
No access to access	20.0% (84)
Access to no access	1.4% (6)
Access to access	74.6% (314)
No access to no access	4.0% (17)
Females (N=119)***	
No access to access	14.3% (17)
Access to no access	1.7% (2)
Access to access	79.8% (95)
No access to no access	4.2% (5)
Web Measures	
2. %Ever used the Web:	
Males (N=409)***	
Never used the Web to used the Web	23.5% (97)
Used the Web to never used the Web	NA
Used the Web to used the Web	70.0% (289)
Never used the Web to never used the Web	5.6% (23)
Females (N=113)***	
Never used the Web to used the Web	31.4% (37)
Used the Web to never used the Web	NA
Used the Web to used the Web	56.8% (67)
Never used the Web to never used the Web	7.6% (9)
Email Measures	
3. %Ready Access to Email:	
Males (N=413)***	
No access to access	28.3% (117)
Access to no access	2.7% (11)
Access to access	64.4% (266)
No access to no access	4.6% (19)
Females (N=117)**	
No access to access	23.9% (28)
Access to no access	9.4% (11)
Access to access	58.1% (68)
No access to no access	8.5% (10)
4. %Currently using email:	
Males (N=419)**	
Not currently using to currently using	7.4% (31)
Currently using to not currently using	2.9% (12)
Currently using to currently using	87.8% (368)
Not currently using to not currently using	1.9% (8)
Females (N=119)***	
Not currently using to currently using	24.4% (29)
Currently using to not currently using	3.4% (4)
Currently using to currently using	66.4% (79)
Not currently using to not currently using	5.9% (7)

***p<.001; **p<.01; *p<.05

Regardless of gender, researchers in Ghana, Kenya, and Kerala are significantly more likely to report shifting from not having ready access to email to having ready access to email (28.3% of men and 23.9% of women) than vice-versa (2.7% of men and 9.4% of women) over the two waves of the survey. This increase in access is reflected in the fact that both men and women are also significantly more likely to identify as current users of email in 2005, than they were in the 2000-2002 period of the study. 24.4% of women identify as current email users in the second wave of the study but did not identify as such in the first wave (compared to 3.4% who moved in the opposite direction). The equivalent numbers for men are 7.4% compared to 2.9%. In other words, over time men and women are both experiencing significant changes in their access to email and in their identification as current users of the technology.

The same trend emerges in terms of access to personal computers in the workplace. Very few respondents, regardless of gender, move from having access to a personal computer to not having access (1.4% of men and 1.7% of women). A much larger percentage of the sample moves in the opposite direction. 14.3% of women and 20% of men did not have personal computers in the first wave but do have access in the second wave. Finally, there have also been significant shifts in use of the Web for both males and females. Men and women are significantly more likely to shift from never having used the web to having used the web than vice-versa (23.5% of men report such a shift and 31.4% of women report the same status shift).

According to table 5.2.1, men and women are not technological drop-outs and have continued to use email and the web over time (row 2). Both males and females have used email and the web for a significantly longer number of years over the two periods (approximately three and a half years for either technology and for both men and women—rows two and five). Both men and women are significantly more likely to use the web and email for a wider variety of

reasons over time (rows 3 and 6), and they are significantly more likely to use email and the web more intensely over the period of a week (rows 4 and 7). The only distinction between the changes that men and women experience over time is in regard to their intensity of PC use. Men are significantly increasing the number of hours they spend using a personal computer, while women are increasing their intensity of use but not significantly so (row 1).

Table 5.2.1: Paired Samples T-test of Changes Access to and use of Personal Computers, the Web, and Email in Wave One and Wave Two by Gender

	Male			Female		
Variable	2000-2002	2005	N	2000-2002	2005	N
Personal Computers						
1. Intensity of PC use	2.81***	3.19	409	2.47	2.67	113
Web						
2. # of years using Web	2.45***	5.97	407	1.50***	5.04	115
3. Extent of Web use	4.38***	7.10	386	3.25***	5.88	112
4. Intensity of Web use	1.16***	2.04	397	.98***	1.75	114
Email						
5. # of years using email	3.83***	7.17	413	2.34***	5.81	118
6. Extent of email use	2.35***	3.03	399	1.79***	2.53	115
7. Intensity of email use	1.56***	1.96	404	1.10***	1.65	111

***p<.001; **p<.01; *p<.05

The first table indicates the presence of persistent gender differences over time on the majority of the technological measures examined. In spite of these fairly consistent differences, the second tables make it apparent that both men and women are significantly likely to be more technologically oriented over time.

Predictors of Access of ICTs

Now, in tables 5.3 and 5.4, I present the results for the multivariate analysis predicting 1) access to ICTs; 2) identification as ICT users; 3) adoption of ICTs; and 4) the intensity and extensity of personal computer, web, and email use. Although I predict the outcomes of ICT behavior on eleven dependent variables, I essentially run two models. In columns two, four, five, and six in table 5.3 and columns three, four, and five in table 5.4 I predict the 2005 outcomes for the various dimensions of technology use while also controlling for the stability

Table 5.3: OLS and Logistic Regression Results for Measures of PC and Web Access and Use

Independent and Control Variables[1]	00-02-2005 Ready Access to PC at Work Exp(B) (N=462)[2]	2005 Intensity of PC use (N=449)[3]	00-02-2005 Ever used the Web Exp(B)[2] (N=461)	2005 Web use experience[3] (N=455)	2005 Extent of Web use [3] (N=436)	2005 Intensity of Web use[3] (N=449)
Constant	2.005	2.961***	6.287***	3.889***	3.606***	1.866***
	(1.024)	(.469)	(1.013)	(1.186)	(.910)	(.372)
Male	1.003	.356*	2.531***	.611	1.161***	.370***
	(.344)	(.143)	(.019)	(.374)	(.283)	(.114)
Age (years)	.958*	-.037***	.908***	-.053*	-.066***	-.028***
	(.021)	(.009)	(.019)	(.024)	(.019)	(.007)
Education (1=PhD)	2.521**	.132	1.780*	.549	.836**	.264*
	(.322)	(.136)	(.270)	(.356)	(.267)	(.106)
Family Structure						
Married (1=yes)	1.034	.062	.324*	-.492	-.332	-.151
	(.505)	(.223)	(.526)	(.601)	(.449)	(.191)
Number of children	.984	.054	.990	-.042	.101	.039
	(.109)	(.048)	(.100)	(.129)	(.097)	(.039)
Spouse a researcher (1=yes)	1.588	-.124	1.255	-.063	.708*	.044
	(.446)	(.171)	(.357)	(.453)	(.344)	(.134)
Localism						
# years in DC	.936	.045	1.195	.244*	.018	-.002
	(.112)	(.047)	(.103)	(.126)	(.097)	(.038)
Context						
Kerala	6.578***	-.133	.761	.345	.207	-.112
	(.403)	(.161)	(.330)	(.442)	(.320)	(.129)
Kenya	3.447***	.010	.557*	.562	.891**	-.228*
	(.321)	(.142)	(.296)	(.380)	(.280)	(.115)
Sector	2.297**	.200	.485**	-.209	-.239	-.214*
	(.304)	(.124)	(.248)	(.318)	(.237)	(.096)
Technology Antecedents						
PC in personal office	3.569***	.169	2.805***	1.305***	.243	.151
	(.743)	(.132)	(.289)	(.345)	(.259)	(.103)
Increase in Comfort using Internet	1.033	.153***	.693***	.859***	1.172***	.356***
	(.101)	(.044)	(.092)	(.114)	(.085)	(.035)
Time lag	---	.289***	---	.551***	.396***	.264***
	---	(.047)	---	(.055)	(.031)	(.044)
R2[4]	.352	.236	.249	.360	.530	.328

[1]***p<.001; **p<.01; *p<.05

[2] Binary logistic regression results

[3] Normal error (OLS) regression results

[4] R-square value for "ever used" is calculated using Nagelkerke correction of the Cox and Snell technique.

effect of the time one measure. For instance, column three in table 5.4 predicts the number of years using email in time two while controlling for the number of years using email in time one.

In columns one and three in table 5.3 and columns one and two in table 5.4, I predict the factors related to *consistent* access to and use of personal computers, email, and the web. In other words, I am not measuring access in general. Rather, I am interested in analyzing the relationship between gender and consistent access to a PC or email or consistent self-identification as an email or Web user from the first to the second wave of the survey. Understanding the factors related to consistent access to a personal computer, email, or the Web, as opposed to simply examining access or use at one point in time, is important as those respondents reporting earlier and more consistent access are also more likely to have the time to develop the skills and knowledge required to use the technologies more extensively.

They may also be privileged in other respects, which may relate to why they have earlier access and use than others. Before going further, it is important to note that access and to some extent current use (whether to a PC, email, or the web) are, to a degree, subjective measures. To begin with, people may interpret ready access and use to mean different things. Some may consider access to refer specifically to the ability to log on to the Internet or send an email message from a personal computer within the home or the workplace. Others may take a more general view considering ready access to mean the ability to use email or the web at a library or Internet café.

Furthermore, the degree to which one perceives him/herself as having ready access to or being a current user of any technology is also tied to feelings of self-efficacy (skill, knowledge, and comfort using various technologies). A person may have access to a personal computer in the work or home office. It may even be connected to the Internet, but if they do not feel

comfortable in their ability to use such tools, they may not perceive the simple presence of the technology as 'ready access.' In other words, access is subjective in nature. Although the first model presented here specifies what is meant by access (i.e. within the workplace), this too is a somewhat subjective measure, though to a lesser degree than simply asking about ready access. To the degree that a person's access to a PC within the workplace is mediated by sharing, using old or malfunctioning equipment, or having a slow connection, a person may not perceive such a situation as lending itself to ready access to a PC or email in the workplace.

In general, a consistent relationship between gender and access to and use of these resources does not appear within the three countries. Although there are a few exceptions, broadly speaking gender is not a significant predictor of the majority of measures analyzed. The most consistent relationship between the independent variables and the measures of resource access and use emerges within the dimension measuring the technological antecedents (with some variation in terms of the specific variables). On nearly all of the outcomes, one or both of these measures emerge as significant predictors.

The first columns in each of the tables focus explicitly on the factors associated with access, either to a PC or email as well as use of email and the Web. Table 5.3 begins by examining the factors related to access to a personal computer. Obviously, if one lacks easy access to the physical hardware required to use the Internet or email, questions related to frequency and diversity of use are irrelevant. Having said that, the results in table 5.3 indicate that long-term access to a PC in the workplace is positively related to possessing a PhD and negatively related to age. In other words, those with a PhD are more likely to report having access to a personal computer at work in both waves of the study (b=2.521), while older respondents are less likely to report consistent access to a PC at work (b=.958). This suggests

that to a degree access to a PC in the workplace over a long period of time may be closely associated with one's position within the workplace. Those with a PhD may simply have more authority, higher rank, and greater pay than those without. The human capital a researcher possesses contributes to a greater degree of access to technological resources. Having a computer in one's office in both waves of the study is also a significant predictor of consistent access to a PC at work. The latter finding may be preliminary evidence for an argument that access is perceptual in nature. Not having to share a computer (or at the very least having more immediate access) leads to a greater perception of accessibility.

Outside of these variables, however, it appears that long-term access to a work PC is primarily a contextual phenomenon predicted by the country and sector within which a person is employed. Those respondents who are employed in a research institute (2.297) in Kenya (3.447) and Kerala (6.578) are significantly more likely to report having consistent access to a PC from wave one to wave two. Stated differently, respondents employed in universities and living in Ghana are less likely to report possessing access to the physical hardware on a consistent, long-term basis. This finding is consistent with the macro figures for ICT penetration reported above and may have implications for researchers in these locations for long-term trends such as shifts in network size and publication counts.

Consistent with the chi-square results presented in table 5.1, gender is not a significant predictor of long-term access to a personal computer at work. Does it relate in any way to consistent access to email or to self-identification as an email or Web user over the two waves? The third column in table 5.3 and the first two columns in table 5.4 present the results for those respondents who reported consistent access to and use of email in times one and two and consistent use of the Web in times one and two. In all three models, gender emerges as a

significant predictor of long-term access to email and identification as an email and Web user. Male researchers are significantly more likely to report long-term access to email (b=2.142), and they are significantly more likely to identify as consistent email users (b=5.036) and to have ever used the Web (b=2.531).

In addition to being male, having a PhD (b=1.780) and a personal computer in one's office (b=2.805) in both waves of the study are also significantly and positively related to using the Web in both waves of the study. Being married is also negatively related to using the Web in both periods (b=.324) as are the majority of the contextual measures with those respondents from Kerala emerging as the only exception. Respondents from Kenya (b=.557) and those working in a research institute (b=.485) are significantly less likely to report using the Web in both waves of the study.

While having immediate access to the physical hardware required to access the Web is positively related to actually using the Web for a long period of time, feelings of comfort with the Internet is actually negatively related to long-term use of the Web (b=.693). This finding is counterintuitive and difficult to explain. It may simply be an anomaly or it may reflect the fact that one's comfort using the Internet does not necessarily translate into the ability to use the Web. It may also be that those who report having used the web in both periods, were highly comfortable to begin with. In other words, they were more likely to identify as Web users *because* their comfort levels were already high so over time their feelings of comfort plateaued. Those people who are not consistently identifying as users of the technology, on the other hand, may also have reported less comfort in the first wave, and thus, they had 'room to grow'.

Outside of gender, the factors predicting consistent access to email over time are distinctly different from the factors predicting consistent identification as a current email user.

Table 5.4: OLS and Logistic Regression Results for Measures of Email Access and Use

Independent and Control Variables[1]	00-02-2005 Ready access to Email Exp(B)[2] (N=438)1	00-02-2005 Currently using email Exp(B)[2] (N=448)2	2005 Email use experience[3] (N=455)	2005 Extent of email use[3] (N=447)2	2005 Intensity of Email Use[3] (N=444)
Constant	.727	2.866	3.951***	1.784**	1.706***
	(.884)	(1.254)	(1.227)	(.568)	(.315)
Male	2.142*	5.036***	.333	.240	.223*
	(.313)	(.358)	(.396)	(.184)	(.101)
Age (years)	.989	.996	-.030	-.029*	-.015*
	(.019)	(.026)	(.025)	(.012)	(.006)
Education (1=PhD)	1.921*	1.558	.681	.616***	.229*
	(.274)	(.377)	(.376)	(.175)	(.095)
Family Structure					
Married (1=yes)	1.140	.534	.157	.193	.161
	(.443)	(.663)	(.626)	(.287)	(.155)
Number of children	.900	.994	-.087	-.066	-.016
	(.096)	(.146)	(.136)	(.062)	(.034)
Spouse a researcher (1=yes)	.998	5.176*	-.452	.022	-.233*
	(.354)	(.768)	(.472)	(.219)	(.120)
Localism					
# years in DC	1.127	1.058	.071	.001	.034
	(.097)	(.162)	(.133)	(.062)	(.032)
Context					
Kerala	4.819***	.415	.068	.056	-.106
	(.369)	(.509)	(.471)	(.209)	(.115)
Kenya	.840	.849	.640	.427*	-.204*
	(.267)	(.477)	(.391)	(.182)	(.100)
Sector	.902	.689	.038	.084	-.243**
	(.254)	(.349)	(.334)	(.155)	(.085)
Technology Antecedents					
PC in personal office	1.426	3.065*	1.522***	.590***	.265**
	(.271)	(.505)	(.361)	(.169)	(.091)
Increase in Comfort using Internet	1.099	1.274*	.319**	.220***	.141***
	(.090)	(.113)	(.120)	(.056)	(.031)
Time lag	---	---	.631***	.462***	.208***
			(.054)	(.041)	(.047)
R2[4]	.228	.244	.361	.388	.219

[1] ***p<.001; **p<.01; *p<.05

[2] Binary logistic regression results

[3] Normal error (OLS) regression results

[4] R-square value for "ever used" is calculated using Nagelkerke correction of the Cox and Snell technique.

None of the dimensions examined emerge as consistent predictors of having long-term access to email. Respondents from Kerala (b=4.819) and those who have a PhD (b=1.921) are more likely to report long-term access to email. The dimension most related to long-term identification as an email user, on the other hand, is related to the technological antecedents. Those respondents reporting a greater degree of comfort using the Internet (b=1.274) and those with a PC in their office in both waves of the study (b=3.065) are significantly more likely to identify as an email user in both periods.

The relationship between these variables seems intuitive enough. Those respondents whose comfort level with the Internet is greater are also more likely to be earlier adopters of the technology and thus to self-identify as current email users. Identification with the technology, as someone who uses and benefits from it, as with having ready access to email, is likely to be formed by ones own feelings of self-efficacy. Finally, having a spouse who is also a researcher is positively related to long-term use of email (b=5.176). Perhaps this is due in part to living in an environment in which technology use is encouraged and shared.

Predictors of Adoption of ICTs

Access is a prerequisite to adoption, but simply having the physical capability to access the web and email does not necessarily translate into the adoption of either. As such, I now turn to examining the factors predicting early adoption of these technologies. Who has been using email and the web longer? What predicts early adoption? Interestingly, after controlling for the other dimensions, gender is not a significant predictor of early adoption. Unlike in the United States, men do not report using the Web or email at an earlier point in time than women. Older respondents are later adopters of the web (b=-.037), but more importantly for the argument regarding localism, those respondents who have spent more time in a developed country are also

earlier adopters of the Web (b=.244). A combination of factors might explain this relationship including exposure and necessity. Spending more time outside of one's country of origin provides a researcher with the opportunity to use the Web earlier where they may not have had such opportunities in less resource rich institutions. In addition, using the technology may be more of requirement in these institutions, an activity that is considered to be a necessity to the research endeavor. Furthermore, the use of chat rooms and other forms of instant communication available through the Web would make it a desirable medium for long-distance communication with family and friends still back in Africa and India.

Age, on the other hand, is consistently negatively related to the adoption of new technologies in almost all of the literature, a finding that is very likely a cohort effect. Younger respondents are more likely to have been exposed to ICTs from an earlier age, whereas older respondents are most likely to have been exposed to the technology mid-career or later. Furthermore, technology adoption rates simply tend to be higher among the most innovative individuals who tend to be younger and in this context, travel more than non-adopters.

The most significant predictor of early email and web adoption, however, is related to the dimension measuring technological antecedents. Those who have had a PC in their office for a longer period of time and those who express more comfort using the Internet over the two waves also began using the Web (b=1.305 and b=.859 respectively) and email (b=1.522 and b=.319 respectively) at an earlier point in time than those people who are less comfortable and do not have a PC in their office. These findings are consistent with the literature coming out of more developed areas. To begin with, although the nature of the relationship between comfort using a technology and one's experience with it is a cyclical one, the literature suggests that a person's perception of him/herself as a skilled technology user is particularly important for initial

adoption. Feelings of technology comfort increases the likelihood that someone will use the technologies at an earlier point of time compared to a person who is less comfortable. Earlier adoption in turn leads to increased feelings of comfort so that initial use may be rooted in comfort but by using the technology a person will become even more comfortable. In addition, as Mohsin (2000) suggests, easy availability is one of the most important predictors of whether or not a person uses a technology. Having a computer in your personal office translates into unmediated use. Those researchers having such immediate access for longer periods of time are also more likely to be earlier adopters of the Web and email.

Predictors of Intensity and Extent of Use of ICTs

As stated previously, over time issues of access and adoption are becoming less and less relevant, and will likely continue to decline in relevance. Now understanding how people *use* the technology and why some use it more diversely and intensely is of more importance for conceptualizing the nature of the digital divide. Turning to the final models in tables 5.3 and 5.4, I examine the extent and intensity of PC, Web, and email use. To begin with, what predicts more intense use of these three technologies? After controlling for the stability effect (i.e. the time one value of the dependent variable), gender emerges as a significant predictor of more intense technology use, regardless of the technology examined. Male researchers use a personal computer for a longer number of hours (b=.356), they use the Web for a longer number of hours (b=.370), and they use email for a longer number of hours (b=.223). Age and human capital also emerge as relatively consistent predictors of intensity of use for all three technologies. Older respondents use a computer (b=-.037), the Web (b=-.028), and email (b=-.015) for a fewer number of hours than younger respondents. But those with a PhD use the Web (b=.264) and email (.229) more intensely than those who are not as educated.

None of the other dimensions are consistently related to the measures of intensity of technology use. For instance, familial structure, human capital, localism, and the contextual dimensions of the research career are unrelated to the intensity of PC use. Outside of the stability effect, the only other variable to emerge as a significant predictor of the number of hours spent using the PC is greater comfort with one's ability to use the Internet. Those respondents who are more comfortable using the Internet over time also spend more time using a PC (b=.153).

Intensity of Web and email use both seem to be mediated primarily by factors related to context and technological antecedents, with one exception. Respondents whose spouses are also researchers report less intense email use (b=-.233). Outside of that exception, respondents from Kenya and those who work in a research institute use the Web (b=-.228 and b=-.214) and email (b=-.204 and b=-.243) for a significantly fewer number of hours. In addition, those researchers who are more comfortable using the Internet over time also use the web (b=.356) and email (b=.141) more intensely. Having a PC in one's office is also a significant predictor of using email more intensely (b=.265). Using a PC in an office, a location that is likely to be relatively private provides a person with more time to engage in online activities without the social pressure to be expedient that might be associated with public terminals. This doesn't, however, translate into more intense Web use.

Do the disparities in intensity of technology use also translate into gender differences in the *types* of activities engaged in while online? According to column five in table 5.3 and column four in table 5.4, being male is significantly associated with more Web use diversity (b=1.161). In other words, male researchers use the Web for a larger variety of reasons, a finding that is consistent with much of the literature on gender and the Internet coming out of

more developed areas. Gender does not, however, emerge as a significant predictor of the extensity of email use. This may be an indication that men tend to use the Internet (whether through their use of the Web or email) for a wider variety of reason, while women tend to use online activities for more restricted purposes, primarily personal relationship maintenance through *communication* technologies.

With a few exceptions, the factors predicting diversity of email and Web use are identical. For instance, older respondents use the Web (b=-.066) and email (b=-.029) for a more restricted number of purposes, while those with a PhD use the Web (b=.836) and email (b=.616) for a wider variety of purposes. Respondents from Kenya also tend to use the Web (b=.891) and email (b=.427) for a wider variety of purposes than respondents from either Kerala or Ghana. Interestingly, reporting a spouse who is also a researcher is positively related to the diversity of activities a person engages in through the Web (b=.708).

Again, this may come down to living with a person who understands and encourages Web use, a person one may share information and ideas gathered through the Web, and a person one could potentially ask questions regarding different Web applications. In other words, it may simply create a more technologically supportive environment. The negative relationship between spousal occupation and email intensity may at first seem to contradict this argument, but I suggest that if one is married to a spouse who is a researcher, particularly if that spouse is within the same field, one may use that person as a sounding board, so that the frequency of email use may not need to be as great as it is for someone who is married to a non-researcher.

On the dimension measuring technological antecedents, increased comfort is a better predictor of extensity of Web (b=1.172) and email use (.220) then is having a PC in one's office. Consistently having the physical hardware to access the Internet is only significantly related to

the extensity of email use (b=.590) and is unrelated to the extensity of Web use. Those respondents reporting unmediated access to a PC are significantly more likely to use email more extensively. Intuitively, it makes sense that those respondents who report having a personal computer in their office would also use email more frequently and for a greater variety of activities than those respondents without a personal computer so easily accessible. Having a PC in one's own office likely means that he/she either does not share with other people or that he/she shares with a smaller number of others thus providing greater opportunity to use email more diversely, for longer periods of time, and more frequently. Comfort using the Internet would be far more important for using email for a variety of activities. Likewise, comfort using the Internet may lead a person to spend more time using email and to send emails more frequently.

Summary

As in the bivariate relationships between gender and the control variables, the findings reported above largely corroborate research coming out of a more developed context. Men tend to be more technologically oriented than women, on a number of measures. However, unlike in the United States, men are not earlier adopters than women. This result may be due to the fact that the respondents are scientists; people who may have a vested interest in adopting new technologies relatively early on, whereas most of the studies coming out of the United States concerning the digital divide sample the general population whose technological behavior is likely very different from that of researchers. Those researchers who report long-term access to the technologies, being earlier adopters of the technologies, and using the technologies more intensely and extensively are also the most innovative individuals in terms of education and age. Family structure and context, on the other hand, do not seem to be consistent predictors of

technological behavior, while the technological antecedents are generally significantly and positively related to technological access and behavior. Technological antecedents are relatively strong predictors of technology behavior, even after controlling for other factors. In particular, having more private access to PC (in one's office) is an especially strong indicator of whether or not one perceives him/herself to have ready access to a PC and whether or not one identifies as a long-term Web and email user. The relationship between gender and technological behavior, though, is by far the most interesting in the context of this dissertation. Do the gender disparities in access to and use of ICTs translate into significant differences in network structure?

CHAPTER 6: PROFESSIONAL NETWORKS

Introduction and Review of the Literature

This chapter addresses the second feature of ICT studies identified by Katz and Rice (2002) related to interaction. Specifically I address two questions: 1) in what ways do men's and women's professional networks differ; and 2) how is access to and use of ICTs related to interaction patterns as measured by network structure?

A central tenant of the social studies of science literature is that science is a communal activity (Beaver and Rosen 1978; Hicks and Katz 1996; Kyvik and Larsen 1993; Luukkonen et. al. 1992; Luukkonen et. al. 1993; Schott 1993). Researchers collaborate and network with their colleagues in the sharing of information and ideas, the publishing of articles, and the evaluation of each other's work.[38] In short, this research points to the fact that establishing and maintaining formal and informal professional contacts is an integral part of the scientific career. It follows, then, that disparities in career outcomes may be linked, at least in part, to disparities in network structure.

By the time men and women reach adulthood they have similar networks in terms of size (Bastani 2007; Campbell 1988; Lin 2000; Smith-Lovin and McPherson 1993). However, their networks differ in significant respects. The most consistent difference to emerge between the networks of men and women in the developed world, one with a number of important consequences for the range and composition of an individual's network, is based on kin vs. non-kin ties (Booth 1972; Marsden 1987; Moore 1990; Smith-Lovin and McPherson 1993).

[38] Collaboration specifically is thought to increase the visibility of researchers through increased publication (Beaver and Rosen 1978). The increasing cost and complexity of research often makes collaborative efforts between researchers a necessity (Lee and Bozeman 2005; Shrum). This idea certainly acts to reify the core producers of scientific knowledge, and the truth of it is dubious. Duque et. al. (2005), for instance, found an inverse relationship between collaboration and productivity with those scientists who collaborate the most being less productive and those who collaborate the least being most productive.

Women's networks are comprised predominately of ties based on kinship whereas men tend to have ties with coworkers and voluntary group members. Although not directly related to the type of social networks examined in this dissertation, the distinction between kin and non-kin *does* have implications for a person's engagement within professional networks.

Professional ties are just one type of social network individuals are engaged in from day to day. People have obligations to other network structures (i.e. networks composed of family and friends). As such, if women tend to be the kin-keepers, reporting stronger ties with kin, this may inhibit or restrict their ability to engage more fully with their professional ties as compared to their male counterparts. Indeed, Campbell (1988) found that the presence of children under the age of six was negatively related to occupational network range and composition for women but not for men. While I do not analyze family and friendship network structures, I do examine the relationship between certain measures of family structure and network composition.

The extent to which these gender differences emerge depends on the boundaries defining the network being examined. The general population of the United States produces the differences noted above, but it has also been observed that those who are employed and with an advanced degree have larger networks and more ties to non-kin, regardless of gender (Moore 1990). In other words, when men and women are in similar structural positions many of the gender differences in kin and nonkin size disappear. Indeed Welch and Melkers (2006), in their examination of the collaborative network structure of scientists and engineers in the United States, discovered that female researchers actually report larger network structures than men. Do gender differences exist in regard to other measures of *organizational* network composition?

According to Ibarra (1993), organizations possess a number of structural features which constrain women's professional ties. Among the factors identified are: 1) the extent to which

women are "present in any particular organizational context" and 2) the extent to which women are "represented in the upper echelons of the firm" (66). Workplaces in the United States tend to be sex segregated with employees in a given occupation being exclusively or predominately male or female (Reskin 1993; Reskin et. al. 1999). This feature of the organizational context leads to one of the most salient findings within the literature regarding sex and professional network structure. Men and women within the workplace tend to have sex homophilous ties; ties composed of same sex others (Ibarra 1993; McPherson et. al. 2001). There is simply less opportunity within the occupational environment to form cross sex networks.

This finding, however, is directly tied to the sex make-up of the workplace. When examining work environments in which there is a mix of males and females, such as within the research context, the finding of sex homophily largely disappears but only for the *minority* sex. For instance, women employed within male dominated institutions report more gender heterophilous ties, while males in the same organization continue to report sex homophilous networks. Although in general it is assumed that more diverse network ties provide access to better resources, this may not be the case for women and racial minorities (Ibarra 1993; Reskin et. al. 1999). Due in part to cultural conceptions about gender roles and stereotypes about the capabilities of women and racial minorities within the workplace, cross-sex interactions may be more difficult to engage in as they are associated with greater costs than same sex interactions. Consequently, when women represent a minority within the workplace, they tend to report feelings of isolation (Reskin et. al. 1999). This argument is particularly significant in relation to the scientific institutions within less developed areas. Although Kerala tends to report more female researchers than either Ghana or Kenya, the scientific institutions in all three locations are male dominated. As such, one expects that men will be more likely to report less gender

diversity within their professional networks and a higher proportion of male contacts, while women will be more likely to report greater gender diversity in their professional networks and a higher proportion of male contacts.

The primary determinant of scholarly community, however, is not solely based on proximity within a department or organization (Schott 1993; Shrum 1997; Shrum and Bankston 1993; Shrum and Beggs 1996; Wellman et. al. 2006). Academic and research endeavors have become increasingly specialized at the same time that university departments attempt to hire faculty with a diversity of research interests. The local, face to face contacts researchers engage in within their departments, universities, or research centers may not be entirely suitable for discussing very specific research topics. In order to find other professionals sharing in one's specialized research area, scientists move beyond intraorganizational boundaries. As such, any analysis of professional networks in less developed countries must go beyond intraorganizational ties to examine contacts with researchers outside of the specific organization.

Studies conducted on the general population in more developed areas regarding proximity and relationship formation and maintenance note that people are more likely to interact and identify with those who are closer in physical space, and these relationships also tend to be *emotionally* closer (Blau 1974; Hurlbert et. al. 2000; McPherson et. al. 2001). Although it has been hypothesized that the Internet might dramatically alter this characteristic of interaction patterns (some go so far as to predict the death of distance), such a change has yet to unequivocally develop. Some studies find that, in spite of the ease of communication associated with the technology, the Internet has not lead to dramatically different ties in terms of geographic location (Wellman et. al. 2001). Even accounting for computer mediated communication, most ties continue to be with people physically close, perhaps not the neighborhood but at the very

least within 100 miles of the home. According to these studies, then, the 'death of distance' in interactions and communications may be a bit of an overstatement. With that said, more recent evidence points to a non-linear relationship between email use and the geographic distance of ties, suggesting that the association between distant ties and ICT use is an evolving one (Mok et. al. 2009). While the number of contacts maintained through email drops with greater distances, suggesting a 'complementary' role for new ICTs and other forms of communication, this association exists only to a point. The number of ties maintained through email rises again for transoceanic relationships.

The majority of these studies have been conducted on the general population's network of close friends and relatives. As a group, these people are likely to use ICTs in distinctly different ways than academics and researchers, particularly those in less developed areas, who may have a vested interest in developing geographically distant ties. Blau (1974), in her study of the important contacts maintained by high energy physicists, noted that geographic proximity was the most important criterion for choosing important contacts. However, this study was conducted in the pre-Internet era when maintaining non-local ties with other researchers required a greater expenditure of time, energy, and money than it does in the Internet era. As travel increases and people disperse, social networks have become more and more diffuse, even global, in character suggesting geography, while still important, may no longer be a determinant of professional network structure.

The available evidence concerning the impact of ICTs on *professional* contacts is mixed. For instance, some studies have noted that computer mediated communication has actually had a positive impact on the creation of *new* ties (Cohen 1996; Costa and Meadows 2000; Freeman 1984; Matzat 2004). Others have found that ICTs have strengthened *existing*

professional ties but either have not examined the creation of new contacts or have found no relationship between ICT use and new tie formation (Carley and Wendt 1991; Cuenca and Tanaka 2005; Wellman et. al. 2006). Matzat (2004) found support for the argument that computer mediated communication helped in the creation of new weak ties, but there was no indication that this led to a regular extension of the researcher's networks. In addition, Wellman et. al. (2006) found that computer mediated communication *complemented* other forms of communication rather than replaced them entirely (Wellman et. al. 2006). Researchers used the Internet, email, and mobile phones in conjunction with face-to-face and landline means in order to maintain professional ties.

Not only does the Internet possess features which may make it a useful tool for developing contacts outside of one's collegial circle, it also may act as a mediator in cross-sex interactions (Castells 2000; Boden and Molotch 1994; Mok 2009; Quan-Haase and Wellman 2002; Wellman et. al. 2006). While not perfect for all or even most communications, in situations of differential status the Internet may act as a means to overcome the limitations inherent within face-to-face interactions. On the one hand, by altering the nature of visual and behavioral cues people use to define action when interacting with one another, the Internet may provide women with the tool they need to benefit from weaker professional ties by counteracting some of the interaction dynamics obstructing their face to face encounters. It may also be used by them to embed themselves more firmly in cross-organizational same-sex networks providing needed social and emotional support.

The other possibility is that the use of ICTs may simply model existing gender inequalities. The Internet does not exist in a vacuum. When researchers sit down at a keyboard, they bring with them their identities, including their stereotypes and prejudices. The same can be

said in regard to geographic heterogeneity and diversity. In theory, networks composed of such ties might lead to better outcomes. In practice, however, such spatially and socially dispersed ties are difficult to maintain and, without effort, decay overtime. While the effect of Internet use on the communication patterns of researchers in developed areas has been found to be positive (with certain qualifications), whether or not similar trends will emerge in developing areas is not certain.

Hypotheses

Technology Use and Professional Network Structure

H1: Respondents using email more extensively over time will report larger professional networks.

H2: Respondents using email more intensely over time will report larger professional networks.

H3: Respondents using email more extensively over time will report more geographically diverse professional networks.

H4: Respondents using email more intensely over time will report more geographically diverse professional networks.

Gender and Professional Network Structure

Given that male researchers report using email more extensively and intensely, I predict that:

H5: Women will report smaller professional networks than their male counterparts.

H6: Women will have less diverse professional networks based on geographic location.

H7: Women will report a larger proportion of domestic contacts than their male counterparts.

H8: Women will report a smaller proportion of foreign contacts than their male counterparts.

Finally given the sex make-up of the research organizations in Kerala, Ghana, and Kenya, I also predict:

H9: Women will have more diverse professional networks based on gender than their male counterparts.

H10: Women's professional networks will have a lower proportion of male contacts than their male counterparts.

Between Group Differences—Independent Samples Test

In the following tables I present the results for various measures of network composition based on the same dimensions as those used in the proceeding chapters. I also incorporate the measures of ICT use including the extent and intensity of email use. I do not include as predictors those respondents who consistently used email or had consistent access to email because these variables are not as useful as they once were in describing the digital divide or people's technological behavior. The majority of the respondents in this survey perceived themselves as users of email in both time periods (94% in time two and 86% in time one), and 90% of the respondents had ready access to email by time 2 of the survey. In addition, Shih and Venkatesh (2002) argue that variety and rate, once adoption has occurred, are more important dimensions for examining technological distinctions between individual technology users.

In table 6.1, I present a series of independent samples t-tests measuring the mean differences between male and female researcher's network characteristics in wave one and wave two. In table 6.2, I turn to examine the differences on the same network measures but within groups. In other words, I examine to what degree male and female researcher's network characteristics have changed from time one to time two. Following table 6.2, I present the OLS regression models predicting the locational and gender diversity of professional contacts, as well

as the number of intraorganizational contacts, the proportion of contacts who are located in either the United States or a European country, the proportion of professional contacts within the immediate environment, and the proportion of professional contacts who are male.

On the majority of the measures analyzed, very few gender differences emerge between males and females in the first wave of the study. Not only do they report nearly identical professional networks in terms of size, their networks are also approximately the same in regards to the size of within country and within continent ties. Their networks are also similar in terms of the number of ties maintained using different means of communication. As a side note, the number of ties maintained by female researchers through email is smaller than the number of ties maintained through other means, whereas males maintain approximately the same number of phone and email ties. Regardless of gender, however, the majority of contacts are maintained through face-to-face contact. While the number of ties maintained through email is approximately the same for males and females, male researchers do report a larger proportion of ties maintained through email (.33 for women compared to .44 for men).

The gender differences that *do* emerge in wave one, are on the measures at the extreme ends of the geographic locations (i.e. the number of ties that are local and the number of ties that are foreign). Women in wave one report significantly more *local* ties, defined as ties to other researchers within Trivandrum, Nairobi, and Accra (1.79 compared to 1.43 ties for men). This difference is also reflected in the proportion of their ties that are local. In the first wave of the study, women had a slightly higher proportion of local contacts within their professional networks than their male counterparts (.47 compared to .37). While women report a slightly larger number of *domestic* contacts in the first wave, they report significantly fewer *foreign* contacts or ties with researchers outside of the continent (.46 ties compared to .86 ties for men).

Table 6.1: Independent Samples T-test of Differences Between Male and Female Researchers in Wave One and Wave Two: Professional Network Structure						
	2000-2002			2005		
Variable	Male[1]	Female	N	Male	Female	N
Professional Network Size	3.83	3.80	500	3.98*	3.50	540
Number of Male Ties	---	---	---	3.58***	2.15	498
Number of Female Ties	---	---	---	.43***	1.41	498
Proportion Male Ties	---	---	---	.90***	.63	498
Proportion Female Ties	---	---	---	.10***	.37	498
Gender Diversity	---	---	---	.24***	.54	498
Number of Local Ties	1.43*	1.79	499	1.60	1.53	525
Number of Within Country Ties	.97	.75	499	1.27*	.97	525
Number of Within Continent Ties	.59	.80	499	.66	.66	525
Number of Foreign Ties	.86***	.46	499	.57	.44	525
Proportion Local Ties	.37*	.47	499	.40	.38	525
Proportion Country Ties	.27	.23	499	.32	.31	525
Proportion Continent Ties	.16	.20	499	.16	.19	525
Proportion Core Ties	.19***	.09	540	.09	.08	525
Locational Diversity	.42	.38	499	.40	.36	525
Number of Face to face Ties	2.09	2.22	499	2.61	2.22	525
Number of Phone Ties	1.85	1.82	499	1.72	1.99	525
Number of Email Ties	1.89	1.46	499	2.49*	2.02	525
Number of Mobile Ties	---	---	---	2.20***	1.50	525
Proportion of Face to Face Ties	.56	.59	499	.64	.58	525
Proportion of Phone Ties	.49	.50	499	.44*	.53	525
Proportion of Email Ties	.44**	.33	499	.60	.56	525
Proportion of Mobile Ties	---	---	---	.54**	.41	525
Multiplexity of Means	1.82	1.71	499	2.39	2.34	525

[1]***p<.001; **p<.01; *p<.05

Again, this finding is reflected in the proportion of ties reported by males and females who are located in the scientific core i.e. the United States and Europe (.09 compared to .19 for men). In other words, in the first wave of the study it is difficult to argue that female researchers are more isolated than their male counterparts *except* on the measure of greatest geographic physical distance. This likely reflects the presence of cultural and economic barriers facing women at a greater rate than men, but it also may simply reflect a different orientation to the research career actively adopted by female scientists.

How do gender differences in professional network characteristics look by the second wave of the study? By 2005, the differences noted in wave one on the professional network structure of males and females have disappeared. Regardless of gender, the respondents report similar network structures within the local environment and abroad which likely reflects the *decrease* in domestic contacts noted by females from wave one to wave two and the *decrease* in foreign contacts reported by males over the same time period. While the gender disparities on these measures have disappeared, four additional gender disparities not noted in the first wave of the study do emerge.

By the second wave of the study, male researchers report significantly larger professional networks (3.98 ties compared to 3.50 for women), they report significantly more contacts within the country but outside of the capital city (1.27 ties compared to .97 for women), and they report significantly more contacts maintained through *email* (2.49 ties compared to 2.02 for women). In other words, the proportion of ties maintained through email has become virtually identical for men and women by wave two, but the number of ties women maintain through email has become smaller. Female researchers also report a higher proportion of contacts maintained through landline telephones (.53 compared to .44 for men) by wave two. The greatest gender disparities

to emerge in 2005, however, are on the measures of the gender composition of the professional networks and the number of ties maintained through mobile phones, information not gathered in the first wave of the study.

To begin with, female researchers report significantly fewer ties maintained through mobile phones than their male counterparts (1.50 ties compared to 2.20 for men). In fact, while male researchers actually maintain more ties through mobile phones than through landlines, the number of ties female researchers maintain through mobile phones is less than all the other measures. These results are confirmed by looking at the proportion of ties maintained through mobile phones. Female researchers maintain significantly fewer ties through mobile phones than do male researchers (.41 compared to .54 for men). Email and mobile phones, the technologies assumed to hold the most promise for women in LDCs, are not being used by this sample of female researchers to the same extent that they are being used by their male counterparts, to maintain professional ties. Regardless of gender, by far the most popular means of maintaining professional contacts is through traditional face-to-face meetings.

Consistent with what one would expect given Ibarra's (1993) argument regarding gender homophily in organizations, female researchers report significantly more female contacts than would be expected given the gender make-up of the work environment (1.41 ties compared to .43 for men), and they also report significantly fewer male contacts (2.15 ties compared to 3.58 for men). Even though women report more female ties when compared to men, the number of ties with male alters exceeds the number of ties women report to female alters. The gender difference in the number of male and female alters, are reflected in the proportion of contacts who are male (women report a significantly smaller proportion of male contacts: .63 compared to .90) and the proportion of contacts who are female (women report a significantly larger

proportion of female contacts: .37 compared to .10 for men). Also consistent with Ibarra's expectations, female researcher report professional networks that are significantly more diverse in terms of their gender composition (.54 compared to .24 for men). In other words, male researchers simply report fewer female alters within their professional network structures, while women are more likely to report both male and female alters.

Within Group Changes—Dependent Samples Test

Above, I examined the gender differences in two time periods on measures of network structure. While instructive, these results say little about whether or not female researchers as a group have experienced any significant changes over time. While gender differences in network structure have changed over time, the question is, 'are these changes in gender differences associated with any significant changes for women as a group compared to men as a group?' In the following paragraphs I examine this question in more detail.

According to the results presented in table 6.2, very few changes have occurred in female researcher's network structure over time. Although not significant, the first row in table 6.2 suggests that female researchers are actually reporting a small drop in the absolute number of professional ties maintained. In terms of the physical location of the ties, female researchers are reporting a significantly smaller proportion of local ties (.39 in wave one compared to .48 in wave two) and a significantly larger proportion of within state/country ties (.31 in wave two compared to .22 in wave one). The drop in the proportion of local ties isn't due to women having more ties in other locations in comparison to the number of local ties. Instead, it is due to the fact that women are genuinely reporting fewer ties on this measure.

Female researchers report significantly more ties maintained through email (2.04 in wave two compared to 1.47 in wave one) and this is reflected in the proportion of email ties they report

Table 6.2: Paired Samples T-test of Differences Between Male and Female Researchers in Wave One and Wave Two: Professional Network Structure

	Female			Male		
Variable	00-02[1]	2005	N	00-02	2005	N
Professional Network Size	3.80	3.55	112	3.83	4.01	388
Number of Local Ties	1.83	1.57	109	1.44	1.58	379
Number of Within Country Ties	.75	.99	109	.97**	1.24	379
Number of Within Continent Ties	.83	.67	109	.60	.69	379
Number of Foreign Ties	.45	.42	109	.87***	.58	379
Proportion Local Ties	.48*	.39	109	.37	.40	379
Proportion Country Ties	.22*	.31	109	.27	.31	379
Proportion Continent Ties	.20	.19	109	.16	.17	379
Proportion Core Ties	.09	.08	116	.19***	.09	407
Locational Diversity	.38	.36	109	.43	.41	379
Number of Face to face Ties	2.27	2.27	109	2.10***	2.57	379
Number of Phone Ties	1.86	2.05	109	1.86	1.74	379
Number of Email Ties	1.47*	2.04	109	1.90***	2.50	379
Proportion of Face to Face Ties	.59	.59	109	.56**	.63	379
Proportion of Phone Ties	.51	.54	109	.48	.44	379
Proportion of Email Ties	.33***	.55	109	.44***	.61	379
Multiplexity of Means[2]	1.72***	2.35	109	1.80***	2.39	379

[1]***p<.001; **p<.01; *p<.05

[2] The large change in multiplexity is due to the inclusion of mobile phones in the second wave of the study. When the time two multiplexity measure is calculated without including mobile phones, the change for women in multiplexity of means was still significant but only at the .05 level (new value=1.94), while the changes for men on the multiplexity of means was not significant (new value=1.86).

(.55 in wave two compared to .33 in wave one). They also report a greater multiplexity of means used to communicate with their professional ties (2.35 in wave two compared to 1.72 in wave one). The increase in multiplexity is due, at least in part, to the added measure of mobile phones as a means of contact in the second wave of the study. When mobile phones are removed from the multiplexity measure, the result continues to be significant but at the .05 level instead of at the .001 level (the time two value is equal to 1.94 when mobile phones are removed from the measure).

Male researchers, on the other hand, are reporting more, though again the difference is not significant, professional ties over the two waves. They are also reporting significantly more within country ties over time (1.24 in wave two compared to .97 in wave one) at the same time that they report significantly fewer foreign ties between wave one and two (.58 in wave to compared to .87 in wave one). The latter finding is also reflected in the proportion of male contacts who are foreign (.09 in wave two compared to .19 in wave one). As noted in chapter four, both males and females report spending more years outside of their home countries for educational or general reasons. However, the greater degree of travel has not translated into a larger number of close, international professional ties for either group. Indeed males are reporting a significant drop in the number and proportion of ties to the core.

The remaining changes in professional network structure reported by male researchers essentially boil down to their face-to-face and email ties. From time one to time two, male researchers are reporting significantly more face-to face and email ties (2.57 face to face ties in time two compared to 2.10 in time one and 2.50 email ties in time two compared to 1.90 in time one). Both findings are also reflected in the proportion of their ties who are maintained through face-to-face and email means (.63 face to face ties in time two compared to .56 in time one and

.61 email ties in time two compared to .44 in time one). Like female researchers, male researchers also report a fairly substantial increase in the multiplexity of means used to maintain contact with their professional ties (2.39 in wave two compared to 1.80 in wave one). Again, this finding is due to the addition of mobile phones as a potential means of contact. When this variable is removed from the multiplexity measure, males report no significant change on this dimension of network structure (the time two value on this measure with mobile phones removed is only slightly greater at 1.86).

Based solely on these measures, than, it does appear that female researcher are becoming more isolated and less integrated in professional network structures on all but one of the four levels of geographic integration measured. Men, on the other hand, are becoming more integrated on all but one of the measures. Although many of the changes are not significant, it is a surprising trend that bares further exploration. Interestingly, at the same time that women are reporting fewer ties, they are reporting an increase on all but one of the measures—they maintain the same number of face-to-face ties over the two waves. Again, this should be interpreted with caution as the changes are not significant. These differences are instructive, but does gender emerge as a strong predictor of network structure when other factors are included in the analysis?

Predictors of Male's and Female's Network Composition[39]

In tables 6.3, 6.4, and 6.5, I present the results for three dimensions of network structure: network size, gender structure, and geographic structure. For each variable within the three dimensions, I present three models: the first model for each dependent measure is the OLS results for the full sample. The second and third models present the gender disaggregated results for males and females as separate groups. The final column in each model presents the results of

[39] In the following tables I present the log of professional network size due to the fact that each of the network measures was positively skewed. I first added a constant value of '1' before taking the log of the variables.

a Paternoster Z test for significantly different effects of coefficients on the outcomes for men and women. Although I include a number of dimensions as predictors of network outcomes, the primary concern in this dissertation is to determine the relationship between gender, changes in ICT use, and network structure. Rather than examine the factors associated with an increase in network size or an increase in the proportion of geographically dispersed contacts, I examine the way in which changes in technological behavior and gender are associated with a person's network structure at time two. In other words, does an increase in the intensity and extent of email use correspond to larger network structures at time two?

Professional Network Size

The first dimension examined relates to one of the more basic measures of network range; absolute network size. As suggested in the discussion on social network analysis presented in chapter two, larger networks are presumed to embed actors within more diverse, broader ranging social ties, and as a result, such networks are assumed to provide ego with access to resources better suited for instrumental outcomes. Regardless of the model, time one network size is positively related to time two network size suggesting a cumulative relationship between time and professional network size.

After controlling for the effect of the lagged dependent variable, gender does emerge as a significant predictor of network size. Men (b=.050) report a larger number of contacts than women. This finding corroborates the relationship between gender and network size noted in table 6.1, as well as Ibarra's (1993) argument regarding the size of women's organizational networks. Women in organizational settings tend to have smaller professional networks, particularly if they are employed in mixed-sex organizations. Interestingly, the gender

Table 6.3: OLS Regression Results Predicting 2005 Professional Network Characteristics

Independent and Control Variables	Size of Professional Network 2005[2] (N=392)				2005 Gender Diversity of Professional Network (N=398)				2005 Proportion of Professional Network who are Male (N=398)				2005 Diversity of Professional Network Locations 2005 (N=391)			
	Full Sample	Males[1]	Females	Z	Full Sample	Males	Females	Z	Full Sample	Males	Females	Z	Full Sample	Males	Females	Z
Constant	.634***	.598***	.943***	-2.29	.572***	.230	.831*	ns	.652***	.942***	.585*	ns	.459***	.534**	.731**	ns
	(.072)	(.089)	(.122)		(.156)	(.184)	(.338)		(.088)	(.085)	(.249)		(.140)	(.172)	(.255)	
Gender (1=male)	.050*	---	---		-.311***	---	---	---	.262***	---	---	---	.089*	---	---	
	(.022)	---	---		(.051)	---	---		(.029)	---	---		(.046)	---	---	
Age (years)	-.002	.000	-.008**	2.22	-.001	-.001	-.001	ns	-.001	.000	-.004	ns	-.003	.000	-.014*	2.09
	(.001)	(.002)	(.003)		(.003)	(.004)	(.008)		(.002)	(.002)	(.006)		(.003)	(.003)	(.006)	
Education (1=PhD)	.017	.038	-.048	ns	.016	.059	-.083	ns	.024	-.043	.205*	-2.80	-.044	-.041	-.142	ns
	(.021)	(.025)	(.039)		(.049)	(.054)	(.115)		(.028)	(.025)	(.085)		(.045)	(.052)	(.087)	
Family Structure																
Married (1=yes)	-.039	-.100*	-.006	ns	.080	-.024	.111	ns	-.024	.008	.088	ns	-.092	-.169	.015	ns
	(.034)	(.044)	(.058)		(.081)	(.103)	(.164)		(.046)	(.047)	(.120)		(.072)	(.092)	(.127)	
Number of children	.007	.009	.006	ns	-.020	-.010	-.049	ns	.006	.004	-.002	ns	.004	-.002	-.002	ns
	(.008)	(.009)	(.016)		(.018)	(.020)	(.046)		(.010)	(.009)	(.034)		(.016)	(.018)	(.035)	
Spouse a researcher (1=yes)	.005	.006	.060	ns	.131*	.119	.226	ns	-.095**	-.098**	-.173	ns	.124*	.048	.302**	-2.10
	(.027)	(.034)	(.045)		(.061)	(.072)	(.130)		(.035)	(.033)	(.096)		(.056)	(.070)	(.099)	
Localism																
Increase in # years abroad	.008	.012	-.022	ns	.005	.011	-.013	ns	.000	-.004	.034	ns	-.005	-.001	-.016	ns
	(.007)	(.008)	(.019)		(.017)	(.018)	(.053)		(.010)	(.008)	(.039)		(.015)	(.016)	(.041)	
Context																
Kerala	-.059*	-.062*	-.060	ns	-.196***	-.205***	-.324	ns	.038	.086**	-.073	ns	-.007	.003	.012	ns
	(.025)	(.027)	(.069)		(.059)	(.062)	(.201)		(.034)	(.029)	(.148)		(.052)	(.057)	(.150)	
Kenya	-.090***	-.068*	-.108	ns	.016	.068	-.195	ns	-.004	-.042	.052	ns	-.064	-.056	-.062	ns
	(.024)	(.027)	(.064)		(.051)	(.054)	(.171)		(.029)	(.025)	(.126)		(.049)	(.054)	(.125)	
Sector	-.001	.028	-.070	2.19	.018	.082	-.139	ns	.019	-.044*	.184*	-2.72	.035	.035	-.004	ns
	(.019)	(.022)	(.039)		(.044)	(.049)	(.110)		(.025)	(.022)	(.081)		(.040)	(.046)	(.085)	
Technology Antecedents																
PC in personal office	.015	.016	-.014	ns	-.057	-.056	-.111	ns	.028	.030	.088	ns	.052	.043	.102	ns
(Both waves)	(.020)	(.022)	(.053)		(.047)	(.049)	(.145)		(.027)	(.023)	(.107)		(.043)	(.047)	(.113)	
Increase in Comfort using Internet	.003	.010	-.009	ns	.009	.018	.007	ns	.009	-.002	.012	ns	.018	.005	.054*	ns
	(.007)	(.009)	(.012)		(.016)	(.019)	(.034)		(.009)	(.009)	(.025)		(.014)	(.018)	(.026)	
Technological Behavior																
Increase in extent of email use	.010*	.008	.011	ns	.005	-.003	.023	ns	-.006	.000	-.015	ns	.006	.014	-.030	ns
	(.005)	(.006)	(.011)		(.012)	(.013)	(.031)		(.007)	(.006)	(.023)		(.011)	(.013)	(.024)	
Increase in intensity of email use	.008	.013	.012	ns	.027	.037	.020	ns	-.014	-.013	-.023	ns	.001	-.015	.086*	-2.15
	(.010)	(.011)	(.019)		(.022)	(.025)	(.053)		(.013)	(.012)	(.039)		(.020)	(.023)	(.041)	
Time lag	.215***	.212***	.208*	ns	---	---	---		---	---	---		.107*	.094	.167	ns
	(.048)	(.055)	(.099)										(.054)	(.063)	(.109)	
R2	.117	.131	.271		.141	.087	.116		.241	.100	.161		.057	.042	.275	

[1] ***p<.001; **p<.01; *p<.05

differences on network size, according to the bivariate relationship, is something that is developing over time, as men and women in the first wave possessed similar networks in absolute size. It is only by the second wave that women report significantly smaller networks than their male counterparts.

Based on the literature concerning the digital divide and the impact of ICTs on network structure, one expects to find a relationship between the measures of technological behavior and network outcomes. Looking only at network size, one would conclude that this prediction is not empirically supported in less developed areas. With one exception, the variables measuring the dimension on changes in the technological behavior of men and women do not appear to be strong predictors of time two network size. An increase in the number of hours spent using email, is unrelated to network size in all three models. Likewise, an increase in the diversity of activities engaged in through email is unrelated for the gender disaggregated models. For the full sample, however, respondents who use email for a wider variety of reasons overtime, also report larger networks at time two (b=.010).

In other words, it is not time spent using email but the types of activities one does while using email that makes a difference for network size. Intuitively, this makes sense. Although there may be an association between the types of activities engaged in while using email and the amount of time spent using the technology, time doesn't necessarily relate in any way to activity. One might spend hours through email discussing a research problem or idea with a colleague who has been a part of one's professional network for years. Another person might spend less time, but engaged in discussion groups with a larger number of people, who he/she may then incorporate within their core network of professional ties as such expanding the absolute size of their contacts.

The dimension most significantly associated with network size is that related to contextual factors. Being from Kerala (b=-.059) and Kenya (b=-.090) is negatively associated with network size for the full sample. Both variables are also negatively associated with network size for men (b=-.062 and b=-.068 respectively) but are not significant predictors of women's time two network size. Male researchers from these locations report significantly smaller networks than men from Ghana. Indeed, examining the bivariate relationship between network size and country of origin reveals that respondents from Ghana report approximately 4.1 professional ties, compared to 3.9 in Kenya and 3.7 in Kerala (results not shown). Interestingly, being employed in a research institute is unrelated to network size in the three models, but the coefficients effect is significantly different for males and females. Women who are employed in a research institute report smaller networks (b=-.070) while men employed in research institutes report larger networks (b=.028). In addition, being married in time one is negatively related to network size for men (b=-.100), while no marriage effect emerges for women. Older women report smaller networks than younger women (-.008), and this effect is significantly different for men and women. Outside of the few exceptions noted above, family structure, human capital, localism, and the technological antecedents of self-efficacy and ease of use are unrelated to absolute network size. While gender may be a significant predictor on this measure of range, it is too soon to suggest that their networks are denser, as absolute network size is but one component to range. There are two additional aspects to measures of range to which I now turn.

Gender Composition of Professional Contacts

In this section, I examine the gender structure of the professional networks in terms of gender diversity of ties and the proportion of ties that are male. To reiterate the argument presented in the literature review, more diverse networks, whether in terms of gender or

geography, are generally assumed to be more useful for certain outcomes. Having more diverse networks is generally considered advantageous for instrumental outcomes because more diverse networks are indicative of a variety of resources. Gender diversity represents the similarity of alters to one another. A network that contains approximately equal numbers of men and women will be closer in value to one, while a network with predominately men or women will be closer in value to zero.

Above, I asserted that interactions mediated through email may be a means of supporting cross-sex interactions in environments in which such interactions may be more tightly constrained than same sex interactions. According to the results presented in table 6.3, however, this does not appear to be the case. After controlling for other factors, none of the technological antecedents or the measures of change in technological behavior, emerges as significant predictors of either measure of the gender structure of professional networks.

By far, the variable most strongly associated with the proportion of male contacts and the gender diversity of alters is the gender of ego. Being male is negatively associated with the gender diversity of professional networks (b=-.311) but positively related to the proportion of contacts who are male (b=.262). In other words, men have less gender diversity in their networks because they are significantly more likely to report a larger number of men. Women, on the other hand, do report more gender diversity in their professional networks, but as I argued above, this is due to the gender make-up of the workplace. Women represent only twenty-two percent of this sample, which likely overestimates the percentage of women in these research systems as a whole and over represents Kerala. The question that needs to be examined, in this regard, is whether or not women are able to turn the diversity of their networks on this measure into more successful career outcomes. In other words, is diversity beneficial, as it is generally

assumed? In chapter seven, I offer a preliminary answer to this question by examining research output.

As with absolute network size, the most consistent dimension predicting the gender composition of the respondent's professional network is that related to context. In particular, being from Kerala is negatively related to the gender diversity of professional contacts for both the full sample (b=-.196) and for male researchers as a group (b=-.205). In other words, men from Kerala report networks composed of alters who are predominately same-sex. Turning to the proportion of contacts who are male, it would appear that the explanation for the latter finding is due to the fact that male researchers in Kerala are significantly more likely to report professional networks with a larger proportion of male contacts (b=.086). In other words, men from Kerala have less diverse ties because they report more homophilous network structures in terms of gender.

This finding is somewhat surprising given the gender make-up of the research system and the historical gender relations in the state. Kerala is often assumed to be a location in which women have enjoyed greater freedoms and more flexible gender roles than in other parts of India. Furthermore, there are more women in the research system in Kerala. This finding provides at least preliminary evidence that the 'add women and stir' argument doesn't apply in this context. The simple presence of women does not mean that men are incorporating them into their professional networks. Of course, it may be that men from Kerala are reporting core professional networks that are less local in orientation, a question I will address in the next section.

In addition to Kerala, sector of employment also emerges as a significant predictor of the proportion of men in the network for both men and women. Women employed in a research

institute report significantly more professional contacts who are men (b=.184), while men employed in a research institute report significantly fewer contacts who are men (b=-.044). The effect of this variable is significantly different for men and women. It should be kept in mind that the professional ties concern people outside of the parent organization of the respondents. As such, this indicates that men and women in research institutes are forming more cross-sex ties outside of their parent organization, leading to networks with a higher proportion of women (for male respondents) and men (for female respondents).

The finding in relationship to women is relatively unsurprising. However, the association between sector of employment and gender composition for men was unexpected. It is not due to women comprising a majority of the employees in research institutes (from chapter four it was noted that women comprise 66% of the university sample and only 34% of the research institute sample). This finding may be related to the nature of work tasks. Scientists in research institutes tend to conduct projects with larger work teams and are perhaps more likely to extend their projects outside of the boundaries of the organization, whereas researchers in the academic sector are more likely to conduct research projects with smaller work teams within the department or university. Perhaps this tendency leads to more frequent cross-sex interactions.

Outside of context, family structure and education also emerge as two dimensions related to the gender composition of professional ties. In particular, being married to a researcher is significantly related to the gender diversity of professional ties for the full sample (b=.131), and it is significantly related to the proportion of male contacts for the full sample (b=-.095) and for men as a group (b=-.098). In other words, being married to a researcher increases the gender diversity of the sample, and as a consequence, it decreases the proportion of contacts that are

male, particularly for male researchers. Being married to a fellow researcher embeds men in networks containing a larger number of women.

Very likely this is due to a combination of factors. First, men's spouses may expose them to a larger number of female contacts than they would otherwise be exposed to if they were not married to a researcher. Second, perhaps being married to a fellow researcher makes it easier for men in this context to form close cross-sex interactions with researchers in other institutes. Being married to a researcher may ease any tensions related to cross sex interactions, and it may provide a sort of safety net from 'office gossip' which may spring up for men with different marital statuses. Third, perhaps being married to a researcher reflects a less rigid notion of gender roles. Male researchers married to another researcher may have distinctly different perceptions about women's capabilities and so may be less resistant (even if on an unconscious level) to form close relationships with other female researchers.

In terms of educational attainment, the effect of having a PhD is only significantly related to the proportion of male alters in female researchers professional networks. Women with a PhD have a larger proportion of men among their close professional ties (b=.205). The effect of having a PhD, furthermore, is significantly different for men and women. In all likelihood, this is due to the fact that having a PhD is more likely to embed one in networks that are more prestigious in terms of rank within a research institute or university. Men make up the majority of researchers in the highest ranking positions. As such, even though most women in this context report ties comprised primarily of cross-sex individuals, a PhD acts to surround one even more with higher ranking (primarily male) ties.

On this second measure of range, women appear to have more diverse, broader ranging networks as men report more gender homophilous ties i.e. more ties with other men and fewer

ties with other women. However, as Ibarra (1993) suggests, diversity on this measure and in an organizational context may not lead to the advantages often associated with broader ranging networks. In fact, Ibarra (1993) suggests that as a minority member within the organizational context reporting a higher proportion of males, while expected, may actually lead to disadvantages for female researchers; feelings of professional isolation being one such disadvantage.

Geographic Composition of Professional Contacts

Finally, in table 6.4, I present the measures of network range related to the geographic location of men's and women's professional contacts. Within the context of the digital divide discussion, ICTs, particularly email, have been predicted by some to be *the* technology for incorporating researchers on the periphery more fully into global scientific networks. This section addresses this contention. After examining the predictors of geographic diversity, I move on to examine the number and proportion of professional contacts based on expanding geographic circles with ego at the center. Beginning with the number of intraorganizational ties, I move on to examine the proportion of ties outside of the respondent's organization but within the country, the proportion of ties outside of the country but within the continent, and finally the proportion of ties in the United States and Europe.

To start, none of the predictors are significantly related to male researchers having a geographically diverse professional network structure including the lagged dependent variable measuring geographic diversity at time one. For the full sample and for women, a handful of variables emerge as significant predictors, suggesting that, at least on this measure, the determinants of career outcomes are distinct for women and men. Turning to the first model predicting geographic diversity for the full sample, gender is significantly associated with the

Table 6.4: OLS Regression Results Predicting 2005 Professional Network Characteristics

Independent and Control Variables	2005 Proportion of Professional Network in the US and Europe (N=416)				2005 Proportion of Professional Ties in Africa and India but Outside Country (N=391)				2005 Proportion of Professional Ties Within Kerala, Ghana, and Kenya but Outside Organization (N=391)				2005 Size of Professional Intraorganizational Network (N=401)			
	Full Sample	Males[1]	Females	Z	Full Sample	Males	Females	Z	Full Sample	Males	Females	Z	Full Sample	Males	Females	Z
Constant	.203**	.194*	.141	ns	.051	.104	.157	ns	.493***	.490**	.436	ns	.608***	.437*	1.106***	-2.00
	(.068)	(.081)	(.128)		(.104)	(.122)	(.233)		(.135)	(.156)	(.281)		(.147)	(.180)	(.282)	
Gender (1=male)	-.025	---	---		.084*	---	---		-.056	---	---		.062	---	---	
	(.022)	---	---		(.034)	---	---		(.043)	---	---		(.046)	---	---	
Age (years)	-.003*	-.002	-.005	ns	-.001	.002	-.007	ns	.006*	.002	.011	ns	.006	.008*	-.001	ns
	(.001)	(.002)	(.003)		(.002)	(.002)	(.005)		(.003)	(.003)	(.006)		(.003)	(.004)	(.006)	
Education (1=PhD)	.001	-.015	.045	ns	.053	.014	.131	ns	-.079	-.020	-.208*	ns	.019	.013	.037	ns
	(.021)	(.024)	(.043)		(.033)	(.037)	(.080)		(.042)	(.046)	(.100)		(.046)	(.053)	(.094)	
Family Structure																
Married (1=yes)	-.032	-.077	.084	-2.11	-.131*	-.173**	.022	ns	.167*	.217**	-.068	ns	-.055	-.008	-.202	ns
	(.035)	(.043)	(.063)		(.053)	(.066)	(.112)		(.067)	(.081)	(.135)		(.074)	(.094)	(.137)	
Number of children	.012	.007	.042*	ns	-.007	-.013	-.001	ns	-.012	.003	-.056	ns	-.024	-.018	-.046	ns
	(.008)	(.008)	(.018)		(.012)	(.013)	(.032)		(.015)	(.016)	(.038)		(.017)	(.019)	(.039)	
Spouse a researcher (1=yes)	.059*	.052	.018	ns	-.023	-.054	-.020	ns	-.025	.039	-.046	ns	.128*	.133	.214*	ns
	(.027)	(.033)	(.050)		(.042)	(.050)	(.088)		(.052)	(.062)	(.106)		(.057)	(.069)	(.107)	
Localism																
Increase in # years abroad	-.002	-.003	.030	ns	.000	-.001	.014	ns	-.002	.001	-.038	ns	.029	.037*	-.051	ns
	(.007)	(.008)	(.021)		(.011)	(.012)	(.037)		(.014)	(.014)	(.044)		(.017)	(.018)	(.045)	
Context																
Kerala	-.050	-.043	-.144	ns	.243***	.302***	.116	ns	-.183***	-.246***	.116	-2.14	-.222***	-.221***	-.160	ns
	(.026)	(.028)	(.075)		(.042)	(.045)	(.136)		(.049)	(.051)	(.161)		(.057)	(.061)	(.169)	
Kenya	-.047*	-.039	-.108	ns	.021	.015	.032	ns	.034	.032	.104	ns	.023	.035	.100	ns
	(.023)	(.024)	(.064)		(.035)	(.037)	(.112)		(.044)	(.046)	(.134)		(.051)	(.056)	(.144)	
Sector	.023	.026	.011	ns	.066*	.054	.077	ns	-.085*	-.068	-.056	ns	.086*	.083	.122	ns
	(.019)	(.022)	(.042)		(.030)	(.033)	(.077)		(.037)	(.040)	(.092)		(.041)	(.047)	(.092)	
Technology Antecedents																
PC in personal office	.018	.035	-.144**	3.02	-.005	-.006	.007	ns	-.024	-.050	.213	-2.04	.140**	.150**	.084	ns
(Both waves)	(.020)	(.022)	(.055)		(.032)	(.033)	(.101)		(.040)	(.041)	(.122)		(.045)	(.048)	(.123)	
Increase in Comfort using Internet	.003	-.001	.012	ns	.018	.012	.019	ns	-.029*	-.014	-.046	ns	-.005	.023	-.068*	2.73
	(.007)	(.008)	(.013)		(.011)	(.013)	(.023)		(.013)	(.016)	(.028)		(.015)	(.018)	(.028)	
Technological Behavior																
Increase in extent of email use	.008	.005	.030**	ns	.005	.009	.000	ns	-.010	-.015	-.026	ns	.010	.001	.024	ns
	(.005)	(.006)	(.012)		(.008)	(.009)	(.021)		(.010)	(.011)	(.025)		(.011)	(.013)	(.025)	
Increase in intensity of email use	-.011	-.008	-.015	ns	-.024	-.027	-.009	ns	.035	.040	.011	ns	.008	.008	.002	ns
	(.010)	(.011)	(.020)		(.015)	(.017)	(.038)		(.019)	(.020)	(.046)		(.020)	(.023)	(.043)	
Time lag	.182***	.144***	.463***	-3.29	.195***	.120	.246*	ns	.155***	.100	.218	ns	.254***	.240***	.307**	ns
	(.034)	(.036)	(.090)		(.049)	(.058)	(.108)		(.047)	(.052)	(.120)		(.052)	(.058)	(.115)	
$R2^3$	.139	.115	.426		.302	.368	.204		.188	.241	.262		.265	.235	.373	

[1] ***p<.001; **p<.01; *p<.05

locational diversity of professional ties. After controlling for the time one measure of geographic diversity (which is positively related to time two geographic diversity i.e. the more diverse the professional network at an earlier time, the more diverse the network in 2005), men report more diverse professional contact locations than do women (b=.089). Men's networks are thus broader ranging on two of the three measures included in this analysis.

While none of the technology measures (in terms of antecedents or changes in behaviors) are significant predictors for the full sample, analyzing women as a group uncovers two measures that are significant predictors of time two geographic diversity. Women who are more comfortable with the Internet over time (b=.054) and who use the Internet more intensely (b=.086) also report more geographically diverse professional networks. More time spent using email has a significantly different effect for men and women. This is consistent with expectations, but it is interesting that the finding is only significant for women. It suggests that, even while women are reporting decreases in ties on the majority of the measures included here, those women who use email more intensely and who are more comfortable with the Internet report professional ties located in a wider number of locations. Technological behavior may be unrelated to the formation of cross-sex ties (which perhaps represents a greater interaction barrier), but the same cannot be said of geographic ties.

Again, having a spouse who is also a researcher emerges as a significant predictor, but in this case for women and the full sample. For both the aggregated sample and women, reporting a spouse who is also a researcher is associated with a more geographically diverse professional network structure (b=.124 and b=.302 respectively). The difference between males and females is significant. Again this seems to be in line with the literature on women scientists in more developed areas. Being married to a researcher has been demonstrated to embed women, in

particular, in more diverse networks, in part because their spouses are likely to have more diverse professional networks. Finally, older women report significantly less geographically diverse professional networks than younger women (b=-.014). The differential effect of age on males and females, furthermore, is significant.

Although not included in the IQV calculation for diversity, intraorganizational professional ties are important for understanding research careers, including outcomes. These people are likely to be the professionals that a researcher interacts with most frequently, both formally through university and departmental committee memberships and informally through casual discussions of research and everyday matters; that is 'water-cooler' talk. Unlike the other measures of geographic professional network diversity, the intraorganizational measure is not based on a proportion but is a simple count of the number of ties within a researcher's respective organization. Controlling for the initial size of intraorganizational contacts is the only variable that consistently predicts the time two size of the network. Those researchers reporting larger time one contacts also report larger time two contacts for the full sample (b=.254), males (.240), and females (.307). Gender is not a significant predictor of intraorganizational ties. After controlling for other factors, men and women report approximately the same number of within organization ties.

Among the variables measuring technology precursors and behavior, reporting consistent access to a personal computer within one's office at work is positively associated with internal network size. For the full sample (b=.140) and for men (b=.150), reporting such access to a computer is associated with a larger number of internal ties. This may be, in part, a function of prestige. Those respondents, particularly men, who have had a PC in their private office over both waves, may also be higher ranking individuals within their respective organizations, leading

larger research teams or being responsible for overseeing the work that is done within a laboratory. As such, they may report more intraorganizational ties in the form of graduate students, lab technicians, and other researchers. Although this variable is not a significant predictor for women's intraorganizational ties, one technological antecedent does emerge as a significant predictor: women who report feeling more comfortable using the Internet over time, also report smaller internal networks (-.068). The effect of this variable is significantly different for men and women.

For the full sample, the dimension most associated to the size of the intraorganizational network at time two is that related to context. Respondents from Kerala report significantly fewer intraorganizational contacts (b=-.222), while respondents employed in a research institute report significantly more intraorganizational contacts (b=.086). The latter finding is unsurprising and is due to the larger number of professional scientists, technical staff, and non-technical staff reported by respondents in the research sector. Employment sector loses its explanatory power when the sample is disaggregated by gender, but the negative relationship between intraorganizational ties and context holds true for male respondents from Kerala (b=-.221). Men in Kerala report fewer intraorganizational ties, which may be related to the large and well-developed research system in India which leads men in this context to seek professional ties outside of their parent organization.

Interestingly, the measure of localism included in this model is positively related to network size, but only for men. Men who have spent more years outside of their respective countries have significantly larger within organization ties (b=.037) compared to men who have not spent such time outside of the country. Intuitively, one might think that travel would increase the size of one's professional network *outside* of the parent organization. This finding,

however, may reflect a self-selection factor. Perhaps those men who travel more also work on more projects, publish more, or perhaps have been employed within their respective organizations longer, thus leading to larger within organization networks.

Two additional factors emerge as predictors of within organization ties. They relate to the sociodemographics of age and to family structure. First, older men report larger professional networks than younger men (b=.008), which may be explained by rank or number of years of employment within the university or research institute. Second, being married to a researcher is significantly related to the size of the intraorganizational network. For the full sample (b=.128) and for women (b=.214), researchers report more ties within their organization if they are married to a fellow scientists.

Intraorganizational contacts represent those associations most proximate to ego. At the intermediate level of geographic closeness, is the proportion of ties within Kerala, Kenya, or Ghana but outside of the parent organization, followed by the proportion of professional ties in Africa and India but outside of the country or state. The predictors significantly associated with these two measures are remarkably similar, but the direction of the relationship is often in opposing directions. To begin with, after controlling for the lagged dependent variable (which is again positively associated with time two network structure), changes in technological behavior do not emerge as significant predictors of time two within country ties or time two ties within Africa and India. This result holds for both the full and the gender disaggregated samples.

However, four exceptions to this general pattern of similarity do emerge, and it is to those that I turn first. Most importantly for the theoretical concerns of this dissertation, the proportion of ties within Africa and India but outside of Ghana, Kenya, and Kerala is significantly related to gender. Men report significantly more ties outside of the country or state, but within Africa or

India (b=.084). Up to this point, gender has been unrelated to the geographic location of professional ties (outside of the measure of geographic diversity). In other words, ties closer in physical space to ego are not affected by gender.

The other exceptions to emerge relate to technological antecedents, age, and human capital. For the full sample, older respondents report a larger proportion of within country ties (.006), while women with a PhD report a smaller proportion of within country ties (b=-.208). Human capital is the only variable to emerge as a significant predictor of the proportion of women's within country networks. Furthermore, this is the only measure of geographic proximity for which educational attainment emerges as a significant predictor and the only one for which the association is consistently negative across the three models. This would seem to indicate that women with a PhD place more emphasis on creating and maintaining ties outside of the immediate environment. Perhaps an advanced degree is associated with a more cosmopolitan perspective, leading to a less local orientation to one's career (at the very least in terms of contacts, if not in terms of travel experiences).

The final exception to the pattern identified above is on the technological antecedent variable measuring increased comfort using the Internet. Those respondents who are more comfortable using the Internet report a smaller proportion of within country ties (b=-.029). The negative relationship between comfort using the Internet and proportion of ties is an interesting one. Turning to the other dependent measures of geographic location of ties, it appears that the relationship between comfort using the Internet and the physical closeness of alters to ego may be an inverse one; the size and proportion of ties closer to ego is negatively associated with comfort but becomes positively associated with comfort the further out in geographic space alters are located. Indeed, although not significant, the relationship between comfort using the

Internet and the proportion of ties in Africa and India and the proportion of core ties is actually positive.

In chapter five, it was demonstrated that increased comfort using the Internet does indeed lead to more intense use of email and the Web. Using the Internet to develop long-distance ties is consistent with recent research coming out of North America in which use of the Internet leads to a larger number of trans-oceanic relationships. This argument, however, should be interpreted with some caution, as it is changes in comfort and not intensity of use that seems to be most related to these measures and then not always significantly so. However, it is certain that increased comfort using the Internet leads to a smaller number (for women) and proportion of ties closer to ego (for the full sample). Finally, although it is not significant for the full sample or for men and women separately, having access to a computer in one's personal office in both waves of the study has a significantly different effect on the proportion of within country ties for men and women. This status is positively associated with within country ties for women, but negatively so for men.

The remaining predictors are those that are significantly related to both the proportion of ties within the country and the proportion of ties within Africa and India but outside of the country. They include: marital status (for the full sample and for men), being from Kerala (for the full sample and for men) and sector of employment (for the full sample). Married respondents have a larger proportion of within country ties (b=.167) but a smaller proportion of ties in Africa and India but outside of the parent country (b=-.131). When disaggregated by gender, married men have a larger proportion of contacts (b=.217) within the country but outside the parent organization but a smaller proportion of contacts in Africa and India (b=-.173).

Context emerges as the strongest predictor of network composition. For the full sample (b=-.183) and for men (b=-.246), being from Kerala is negatively associated with the proportion of ties within the country. The effect of this variable is significantly different for men and women, as women from Kerala have a larger proportion of ties on this level of geographic closeness, though not significantly so. This is the only measure of geographic location so far, for which being from Kerala is positively associated with the proportion of ties. Turning to the proportion of ties outside of the country but within Africa and India, both the full sample (b=.243) and men (b=.302) who are from Kerala have a larger proportion of ties outside of the country or state but within Africa or India.

This provides preliminary support for the assertion made earlier regarding the smaller number of intraorganizational ties for men in Kerala. Both within the organization and within the state, men in Kerala report a smaller number of professional ties perhaps because of more developed national research system. For men in Kerala, the incentives to form ties with the national research system, as opposed to the state, may encourage them to seek contacts outside of the immediate environment, and the opportunities exist to do so. In addition, for the aggregated sample, being employed in a research institute (b=-.085) is negatively associated with the proportion of within country contacts but positively associated with the proportion of ties in Africa and India but outside of the country or state (.066). These findings provide support for the notion that geography should not be examined in a simple core/periphery dichotomy. Instead Schott's concentric circles mapping the integration of researchers in the scientific community is relatively useful for arriving at more nuanced distinctions determining the location of researcher's ties. The final geographic location that needs to be examined, then, is related to the proportion of contacts at the core.

In the final column examining the geographic location of professional ties, I predict the proportion of the researchers' professional contacts that are located in more developed areas, specifically the United States and Europe. It is at this level of geographic proximity that email and the Internet are predicted to have the largest impact. The strongest predictor of the proportion of ties at the core for the full sample (b=.182), men (b=.144), and women (b=.463) is the lagged dependent variable. Those respondents who had larger core networks at time one have larger core networks at time two. Outside of this measure, none of the predictors emerge as significantly related to the proportion of male researchers' contacts who are located in the scientific core. In addition, gender is unrelated to this measure. After controlling for other factors, men and women report approximately the same number of ties in the United States and Europe. This finding is consistent with the bivariate relationship between gender and foreign ties examined in table 6.1. According to that table men's and women's core network structure became more similar overtime due primarily to the significant drop by wave two of the study in the number of ties male researchers reported.

For the full sample and for women, a handful of additional measures emerge as significant predictors of the proportion of core contacts. Among the variables of primary interest for this study, two emerge as significant predictors of female researchers' core contacts. An increase in the number of activities engaged in while online (b=.030) and having a computer in one's personal office in both waves of the study (b=-.144), are both significantly related to the proportion of female researchers' contacts that are located in the core. Engaging in wider variety of online activities is positively related to a higher proportion of core contacts, while consistent access to a PC in ones office is actually negatively associated with female researcher's core contacts. In other words, more email activity over time leads to larger core networks by time

two. At first, it might appear that the latter finding related to ease of access to a personal computer is counterintuitive. However, it is important to remember that this is a measure of hardware not connectivity. Simply have easy to a personal computer is not enough to extend the proportion of ties outside of one's country of origin. It has to be connected to the Internet. The effect of consistent access to a computer within the work office, furthermore, is significantly different for men and women.

Finally, two measure of family structure, age, and one contextual measure also emerge as significant predictors of the proportion of core contacts. First, older respondents report a smaller proportion of core ties (b=-.003), as do Kenyan respondents (b=-.047). While one might expect younger respondents to have more ties in this location (as they are also the ones who are most likely to travel), the finding in regards to Kenya is somewhat surprising. Previous research in this area has noted that Kenyan respondents tend to report a greater number of collaborations with foreign researchers. Although this is a measure of professional and not specifically collaboration, it is still interesting to note a reversal in overseas contacts. It may reflect a decaying effect. Long-distance relationships, even those based on close, expressive associations, are difficult to maintain. While the Internet may provide a medium through which these contacts can be established, it may not be ideal for the *maintenance* of such ties.

Finally, along the family structure dimension, women with children (b=.042) and being married to a researcher for the entire sample (.059) are both positively related to the proportion of ties at the core. Women who have more children also have more core ties. Likewise, being married to a researcher is associated with more core ties. Although not significant for either males as a group or females as a group, the effect of marital status on the proportion of core

contacts has a significantly different impact between males, (a negative relationship) and females (a positive relationship).

Summary

A number of the predictors emerge as significantly related to measures of professional network structure including gender, age, and family structure. Women tend to report more gender diversity within their professional ties and a smaller proportion of male ties, while men report more geographically diverse ties. Being married to a researcher embeds the respondents in more geographically and gender diverse networks. Older respondents tend to have less geographic diversity in their professional ties and a larger proportion of ties closer in geographic space. The most consistent predictor of network structure in 2005 is within the contextual dimension. Respondents from Kerala tend to have a smaller proportion of ties closer in geographic location and a larger proportion of ties further out, but only to a point. Respondents from Kerala have a larger proportion of within continent (but external to country) ties. Finally, the technological antecedents tend to be more closely associated with the geographic nature of professional network, but are unrelated to the gendered nature of professional ties. Human capital, localism, and changes in technological behavior are largely unrelated to the majority of the measures examined.

CHAPTER 7: CAREER OUTCOMES

Introduction and Review of the Literature

In this final chapter, I turn to the third element of ICT studies identified by Katz and Rice (2002) related to involvement. Although their study is primarily concerned with the way in which ICTs effect community participation, in a broad sense, I am concerned with the way in which ICT access and use is related to involvement within the scientific community. In this regard, I examine three questions: 1) how is access to and use of ICTs related to productivity; 2) how is professional network structure related to productivity; and 3) in what ways do men's and women's research output differ?

There are a number of means for evaluating the contribution of researchers, disciplines, and institutions to the scientific endeavor including the receipt of awards and grant money and the successful mentoring of undergraduate and graduate students. Within research institutes and universities, one of the most accepted and objective measures of contribution to science, specifically to the creation of new knowledge, is productivity accessed through publications in peer reviewed journals, books, and chapters in edited volumes (Najman and Hewitt 2003).[40] Publication productivity may be a simple measure of scientific output but not an uncontroversial measure. There are a number of problems inherent within measuring scientific output through productivity. In particular, such a measure doesn't distinguish between sole and multi-authored publications or between articles published in first, second, or third tier journals. Citation counts based on an author's name over looks research output in other channels.

The issue of scientific productivity is particularly relevant for the study of gender differences within science. Because publications are related to the evaluation of a researcher's

[40] By including a number of measures of research output (not simply work that has been published), the findings reported below more accurately reflect research productivity.

efforts, productivity is both a cause and a consequence of academic rank, promotion and salary. Science is a stratified institution regardless of the sex of the individual scientist with the shape of productivity being positively skewed. In other words, a few highly productive male and female researchers represent the majority of the publications produced each year. Most researchers either publish very little (if at all), or the number of papers they publish falls somewhere in between the extreme of none to many. With that said, numerous studies document the lower productivity levels of female researchers in comparison to their male counterparts (Cole and Zuckerman 1984; Fox 1995; 1996; 1999; 2005; Long 1992; Xie and Shauman 2003). Few of these studies offer satisfactory explanations for the relationship between publication counts and gender. In fact, Cole and Zuckerman (1984) refer to this phenomenon as the 'productivity puzzle' due to its persistent and seemingly inexplicable presence. Few studies, however, have examined the gendered nature of productivity as it relates to professional network structure and the use of communication technologies.

Social networks are argued to be important determinant of outcomes due to resources. Social ties contain resources or potential resources. When activated such resources make the outcomes of action more or less likely, depending on the type of outcome and the resources exchanged. In the previous chapter's literature review, I noted gender differences in network structure. One of the most consistent findings within the literature concerning the network structure of the general population is that women tend to have more kin based ties. These types of ties are more likely to be strong and dense, thus providing women with greater access to social support but decreased access to non redundant information. Men, who tend to have more non-kin relationships in their networks, have more access to instrumental resources (Hurlbert et. al. 2000).

More to the point of the network structures examined in this dissertation, there also tend to be gender differences in regards to measures of geographic and gender homophily and diversity. Such measures are important primarily because different network structures are thought to provide access to different types of resources. Within the social network analysis literature, it has been demonstrated that certain network structures are more beneficial than others for acquiring certain types of outcomes. Typically, larger, more diverse and heterogeneous networks composed of weaker ties are thought to be more beneficial for obtaining instrumental outcomes—such as the receipt of formal aid or the sharing of information that can be used for such things as publication or funding opportunities, by distributing the flow of information between diverse actors (McPherson et. al. 2001). Denser, smaller networks, composed of stronger ties, on the other hand, are better suited for expressive outcomes such as the provision of informal support in the form of advice, money, transportation, and companionship (Taylor 1986).

In general, it is assumed that weak ties, marked by heterogeneity between alter and ego and more diversity among alters, are more beneficial to instrumental, particularly career outcomes than are stronger, more homogenous and less diverse social networks. However, Ibarra (1993) has pointed out that for women and racial minorities the benefits associated with the latter type of social network structure may not be accessible to them but because of the disparities in gender and racial status within organizations, women and racial minorities may lack any other options in their tie formations. Within the male-dominated hard sciences, particularly in academic settings, cross-sex relationships may be weaker in nature due to the fear of negative repercussions stemming from close, expressive ties with a member of the opposite sex causing such ties to provide a "narrower range of benefits for women" (Ibarra 1993: 71). In

other words, the sex make-up of the work place may entail that female researchers have more gender diverse professional networks, but having a larger number of males in their professional network may not offer them the same benefits afforded to male researchers with an equivalent number of same-sex contacts. Consequently, female researcher's organizational and professional ties may not provide them with resources consistent with successful instrumental outcomes such as productivity.

In chapter six, I examined the relationship between access to and use of ICTs and gender differences on various measures of network structure. The Internet possesses features that may change not only the informal and formal communication patterns of developing area researchers but also their productivity levels (Barjak 2004; Matzat 2004; Ynalvz et. al. 2004). Although the literature is not extensive and the data is often old, there is some evidence that the relationship between technology use and productivity is positive. Costa and Meadows (2000), using a sample of sociologists and economists noted that in the Brazilian context technology use increased career outcomes.

Hypotheses

Professional Network Structure and Career Outcomes

H1: Respondents with larger professional networks will produce more in foreign venues

H2: Respondents with larger professional networks will produce more in domestic venues

H3: Respondents with more geographically diverse professional networks will produce more in foreign venues

H4: Respondents with more geographically diverse professional networks will produce more in domestic venues

H5: Respondents with more gender diverse professional networks will produce more in foreign venues

H6: Respondents with more gender diverse professional networks will produce more in domestic venues

ICT Use and Career Outcomes

In the previous chapter, I examined the relationship between access to and use of ICTs and gender differences on various measures of network structure. The Internet possesses features that may change not only the informal and formal communication patterns of developing area researchers but also their productivity levels (Barjak 2004; Matzat 2004; Ynalvz et. al. 2004).

H7: Respondents using email for a wider variety of reasons over time will produce more in foreign venues

H8: Respondents using email for a wider variety of reasons over time will produce more in domestic venues

H9: Respondents using email more intensely over time will produce more in foreign venues

H10: Respondents using email more intensely over time will produce more in domestic venues

Gender and Career Outcomes

As observed in the previous chapter women's professional networks are smaller, less diverse geographically, and more diverse in terms of gender make-up. In light of these findings, I also expect

H11: Women will produce less in foreign journals

H12: Women will produce more in domestic journals

Between Group Differences—Independent Samples Test

Tables 7.1 and 7.2 present the results for the independent and paired samples t-test for gender differences and changes over time on the eight productivity measures. Following the bivariate analysis of the relationship between gender and productivity, I present the multivariate analysis predicting logged productivity at time two based on gender, technology use and behavior, the professional network measures, and the control variables. The productivity counts are based on self-reported assessments. While using self-reported publications has been criticized due to issues of reliability, it is useful for getting at research output outside of the generally accepted journal and book venues. I organize the multivariate analysis according to the type of publication as follows: working papers and conference presentations, bulletins for extension and reports, and finally publications in more mainstream venues (chapters in books and domestic and foreign journals).

According to the results in table 7.1, few gender differences in productivity exist in either wave of the study. Male and female researchers in both time periods produce approximately the same amount of output in nearly all of the venues examined. Two gender differences do emerge, however, and they are persistent across waves. Both of the measures of gender differences, furthermore, relate to research output in international or foreign venues. Not only do female researchers present significantly fewer papers at international conferences than males in both waves of the study (1.24 articles in wave one compared to 1.80 articles for men and 1.38 articles in wave two compared to 2.08 articles for men), they also publish fewer articles in foreign journals in both waves (.94 articles in wave one compared to 2.10 articles for men and 1.01 articles in wave two compared to 3.33 articles for men). [41]

[41] As a side note, a colleague working on data gathered in the Chilean scientific context found that women were actually publishing *more* than their male counterparts in foreign journals.

Table 7.1: Independent Samples T-test: Differences in Productivity Between Male and Female Researchers in Wave One and Wave Two

	2000-2002			2005		
Variable	Male[1]	Female	N	Male	Female	N
Productivity[2]						
#Papers at state or national workshops	4.27	4.41	487	5.53	5.50	532
#Papers at international conferences	1.80*	1.24	468	2.08**	1.38	520
#Reports	4.68	4.98	481	6.71	5.91	526
#Bulletins for extension	1.15	1.05	440	1.75	.91	513
#Research papers written in past year	2.95	3.12	482	3.99	3.56	517
#Articles in foreign journals	2.10***	.94	447	3.33***	1.01	525
#Articles in national journal	2.50	2.81	466	2.75	3.15	521
#Chapters in books	.68	.59	424	1.01	.90	515

[1]***p<.001; **p<.01; *p<.05

[2] Except for the number of papers written, the measures of research output is for the period between 2000 and 2005

In addition, female researchers are actually more productive, though not significantly so, in the national context (measured in terms of both papers presented at workshops and published in national journals, although the former trend reverses slightly by the second wave). These findings suggest that the geographic component to the research endeavor extends beyond professional relationships to research output, and may be related to the phenomenon of localism observed by Anderson and Shrum (2007), Campion and Shrum (2004), Miller et. al. (2006), and Palackal, et. al. (2006). Female researchers may face greater structural constraints inhibiting their international travel than their male counterparts leading to lower levels of research output in foreign venues.

Within Group Changes—Dependent Samples Tests

While gender differences do not seem to be great in regards to the majority of measures of research output, the next issue that needs to be addressed is whether or not there have been any significant changes for males and females as two distinct groups from the first to the second wave. Female researchers are reporting very few significant changes over the two time periods in research output. Although generally reporting slight increases in research output, very few of

the indicators are significantly different over time. Two exceptions emerge: women are significantly more productive in terms of the number of research papers written, whether published or unpublished (3.13 papers in the first wave compared to 3.66 papers in the second wave), and women are publishing more chapters in edited volumes over time (.59 chapters in the first wave compared to .91 chapters in the second wave). Outside of these two exceptions, women's research output is relatively stable over time, at least over this relatively short interval.

Male researchers, on the other hand, report a significant increase in research output on all but two of the indicators examined: the number of bulletins for extension and the number of articles published in national journals (and even for these measures they are reporting a slight increase). Male researchers are more productive across the two waves in terms of the number of papers presented at national (4.29 papers in wave one compared to 5.85 papers in wave two) and international workshops and conferences (1.77 papers in wave one compared to 2.21 papers in wave two), they report more output in terms of the number of reports (4.69 reports in wave one compared to 6.65 reports in wave two) and research papers written (2.97 papers in wave one compared to 4.17 papers in wave two), and they are publishing more articles in foreign journals (2.11 article s in wave one compared to 3.70 articles in wave two) and more chapters in books (.69 chapters in wave one compared to 1.00 chapters in wave two). In other words, comparing males to females reveals few differences between the two groups of researchers. Examining changes for each group, however, reveals that over time men's productivity is increasing at a greater rate.

Studies conducted in more developed contexts note that gender differences in research productivity is closely related to the number of years working. Long (1992), for instance, observed different patterns of research output for male and female researchers working in the

Table 7.2: Paired Samples T-Test: Changes in Male and Female Productivity Over Time

	Female			Male		
Variable	2000-2002[1]	2005	N	2000-2002	2005	N
Productivity						
#Papers at state or national workshops	4.44	5.56	113	4.29***	5.85	368
#Papers at international conferences	1.24	1.38	111	1.77*	2.21	345
#Reports	5.00	6.04	112	4.69***	6.65	359
#Bulletins for extension	1.04	.94	109	1.14	2.04	319
#Research papers written in past year	3.13*	3.66	106	2.97**	4.17	358
#Articles in foreign journals	.94	1.02	109	2.11**	3.70	331
#Articles in national journal	2.83	3.34	109	2.52	2.92	345
#Chapters in books	.59*	.91	108	.69*	1.00	312

[1]***p<.001; **p<.01; *p<.05

United States. Gender differences in publication patterns are quite small immediately following graduate school. As more time passes, however, the gender differences become larger with male researchers scientific output outpacing their female counterparts but only to a point. While both males and females are reporting slight (females) increases in productivity, the larger increases for males may be a reflection of this pattern. This trend, however, is not inevitably bound to persist over time. In fact, Long also noted that by the ninth year of the research career, while gender differences don't disappear, they do become smaller, as male researcher's productivity levels off and female researchers continues to rise. However, his study was done over a period of approximately two decades. On average, only four years has passed between wave one and wave two of this study. As such, it is too soon to say whether or not gender differences in productivity in Ghana, Kenya, and Kerala are markedly different from the gender differences found in the United States. Now, I turn to the predictors of research productivity.

Predictors of Research Productivity—Presentations and Non-Published Works

The first measure of productivity I examine relates to productivity more generally in terms of non-published works. One of the more consistent criticisms associated with the use of publication counts is the fact that it overlooks other types of research output. Publication is often the last step in the productivity process. The first three measures of productivity correspond to what might be considered the earlier stages in the research process. As with chapter six, each of the tables measuring research output presents the results across three models: the first model for the aggregated sample and the second two for the gender disaggregated sample. The final column for each dependent variable presents the results of the Paternoster Z score test.

The first dependent variable in table 7.3 analyzes the number of research papers written in the period between the summer of 2004 and the summer of 2005. This measure includes the

total number of research papers written regardless of whether or not they were actually published. The second and third dependent variables concern research output in terms of conference and workshop presentations done in the period between 2000 and 2005. The stability effect measuring the time one productivity levels is the most consistent predictor of time two research output across all three measures and all three models—except for women's attendance at international conferences. More productive researchers at earlier points in time, continue to be more productive later in their careers. Across all three measures of research output presented in table 7.3, and consistent with the bivariate relationships between gender and productivity, respondent's gender is not a significant predictor of productivity in any of the models examined. Controlling for other factors, men and women write approximately equal numbers of research papers and present approximately equal numbers of articles at national workshops. Although men, in the bivariate analysis, do present significantly more papers at international conferences, when other factors are controlled for, this difference disappears. Men and women are approximately equally productive in these three areas.

With a few exceptions, the dimensions measuring family structure, localism, context, technology antecedents, and changes in technological behavior are not good predictors of research output in these venues. Indeed, the only technology measure to emerge as a significant predictor of research output is an increase in comfort using the Internet. For the full sample (b=.037) and for women as a group (b=.061), those who report feeling more comfortable with their Internet use across the two waves also present more papers at national conferences and workshops. Regardless of the dependent variable or the model, none of the other technology behaviors are significant predictors of output. However, an increase in the number of activities done through email does have a significantly different effect for men and women in terms of the

Table 7.3: OLS Regression Analysis for Papers written and Presented at National and International Conferences by 2005

	Number of research papers written in the past year 2005 (N=328)				Number of papers at state or national workshops 2005[2] (N=338)				Number of papers at international conferences 2005[5] (N=321)			
Independent and Control Variables	Full Sample	Males[1]	Females	Z	Full Sample	Males	Females	Z	Full Sample	Males	Females	Z
Constant	.632***	.651***	.565*	ns	.469**	.715***	.035	ns	.294*	.533**	-.004	ns
	(.121)	(.152)	(.221)		(.169)	(.211)	(.347)		(.149)	(.194)	(.293)	
Gender (1=male)	.045	---	---		.055	---	---		.086	---	---	
	(.039)	---	---		(.051)	---	---		(.045)	---	---	
Age (years)	-.005	-.005	.000	ns	-.004	-.006	.005	ns	-.003	-.004	.000	ns
	(.003)	(.003)	(.005)		(.003)	(.004)	(.007)		(.003)	(.004)	(.006)	
Education (1=PhD)	.080*	.043	.117	ns	.112*	.165**	-.084	2.10	.177***	.181***	.134	ns
	(.037)	(.046)	(.062)		(.049)	(.057)	(.104)		(.044)	(.052)	(.087)	
Family Structure												
Married (1=yes)	-.016	-.013	-.082	ns	-.172*	-.329**	-.216	ns	-.084	-.184	.032	ns
	(.062)	(.089)	(.089)		(.083)	(.118)	(.134)		(.073)	(.107)	(.120)	
Number of children	.008	.019	-.040	2.01	.032	.051*	.009	ns	.006	.004	.027	ns
	(.014)	(.017)	(.024)		(.018)	(.022)	(.039)		(.016)	(.020)	(.037)	
Spouse a researcher (1=yes)	.053	.029	.157*	ns	.038	.101	.008	ns	-.019	-.068	.137	ns
	(.045)	(.057)	(.071)		(.060)	(.074)	(.113)		(.052)	(.063)	(.100)	
Localism												
Increase in # years abroad	.020	.028	-.016	ns	.002	.024	-.106*	2.85	.010	.010	.000	ns
	(.013)	(.015)	(.026)		(.016)	(.018)	(.042)		(.014)	(.016)	(.035)	
Context												
Kerala	-.025	-.013	-.052	ns	.122*	.102	.401*	ns	-.024	-.005	.025	ns
	(.046)	(.051)	(.129)		(.061)	(.066)	(.191)		(.057)	(.064)	(.188)	
Kenya	-.114*	-.125*	.002	ns	-.010	-.026	.305	ns	-.050	-.070	.063	ns
	(.044)	(.049)	(.121)		(.060)	(.065)	(.178)		(.056)	(.062)	(.179)	
Sector	-.022	-.019	-.014	ns	.021	.056	-.065	ns	.021	-.016	.107	ns
	(.032)	(.040)	(.059)		(.043)	(.051)	(.091)		(.038)	(.046)	(.078)	
Technology Antecedents												
PC in personal office	.015	.015	.069	ns	.026	.024	.002	ns	.040	.037	.097	ns
(Both waves)	(.035)	(.040)	(.079)		(.046)	(.050)	(.129)		(.041)	(.045)	(.118)	
Increase in Comfort using Internet	-.004	-.003	-.002	ns	.037*	.026	.061*	ns	.018	.015	.016	ns
	(.011)	(.015)	(.018)		(.015)	(.019)	(.028)		(.013)	(.017)	(.024)	
Technological Behavior												
Increase in extent of email use	.011	.019	-.022	2.03	.011	.018	-.032	ns	.013	.019	-.005	ns
	(.009)	(.011)	(.017)		(.012)	(.013)	(.026)		(.010)	(.012)	(.023)	
Increase in intensity of email use	-.017	-.024	.029	ns	.000	.011	.017	ns	.019	.026	.014	ns
	(.017)	(.021)	(.027)		(.022)	(.026)	(.042)		(.019)	(.023)	(.037)	
Professional Contacts												
Increase in network size	-.011	-.110	.407**	-3.29	-.077	-.098	.085	ns	-.201*	-.269**	.083	ns
	(.071)	(.085)	(.132)		(.095)	(.109)	(.208)		(.083)	(.098)	(.180)	
Gender diversity (time two)	.067	.055	.057	ns	.125*	.095	.153	ns	.075	.127*	-.024	ns
	(.038)	(.048)	(.059)		(.050)	(.061)	(.094)		(.044)	(.055)	(.079)	
Increase in geographic diversity	-.021	.017	-.126*	1.96	-.044	-.052	.022	ns	.089*	.115*	.012	ns
	(.035)	(.043)	(.059)		(.046)	(.054)	(.093)		(.041)	(.050)	(.078)	
Time lag	.135***	.168***	.077**	2.47	.131***	.135***	.154***	ns	.122***	.139***	.060	ns
	(.019)	(.025)	(.027)		(.020)	(.023)	(.041)		(.019)	(.023)	(.045)	
R2[3]	.262	.284	.448		.255	.287	.379		.275	.314	.281	

[1]***p<.001; **p<.01; *p<.05

number of papers written. Men who use email more diversely over time report more papers written in the last year, while women who use email more diversely over time report fewer papers written in the last year. For this first stage in the research process, then, technological behavior is not having any significant effect on the research systems in less developed areas.

Across the three measures of research output, the dimensions most related to productivity are human capital and professional contacts. Increases in absolute network size and in the geographic diversity of contacts are the most consistent measures associated with productivity. Although neither measure of network changes emerge as significantly related to the number of papers presented nationally, the gender diversity of professional ties does. For the full sample, those reporting more gender diversity in their professional networks (i.e. a more gender balanced professional network), report more papers presented at national workshops and conferences (b=.125). Although this finding emerges for the full sample and not for the disaggregated sample, based on the results in chapter six, women do have more gender balance in their professional networks then men do. As such, it may be that diversity on this measure of network composition *is* related to instrumental outcomes, at least in terms of conference attendance.

Additionally, more gender balanced networks are also positively associated with the number of papers presented at international conferences (b=.127), but on this measure, the association only emerges for male researchers. It may be that gender balanced networks in some contribute to access to information about international conferences or access to funding opportunities to support travel to international conferences. Or it may simply be that by attending international conferences, men are exposed to more female professionals who they then incorporate into their professional ties.

The other two measures of professional contacts emerge as significant predictors of the number of papers written and the number of articles presented at international conferences, but the direction of the relationship depends on the context of the output. For instance, women who report more professional contacts over time also writing more papers (b=.407). This is a rather large coefficient and it produces significantly different effects for men and women. In other words, women are able to translate the absolute size of their professional ties (a measure of range) into more productive outcomes in the initial stage of the publication process (i.e. writing papers). Men, on the other hand, report a negative association between the two measures (although the result is not significant). While absolute network size appears to be positively associated with this measure of research output, women are not able to translate in increase in geographic diversity of professional ties into more productive outcomes on the same measure. An increase in the geographic diversity of professional ties is negatively associated with the number of research papers written by women (b=-.126), and the effect is significantly different by gender. This may, in fact, be an indication of the amount of effort required to maintain more geographically diverse contacts. Placing more time and energy into maintaining ties located at greater distances from oneself may limit the amount of time one has to actually write.

A reverse trend emerges, however, when I turn to the measure of foreign outcomes measured in terms of the number of papers presented at international conferences. An increase in the geographic dispersion of one's professional ties is positively associated with the number of papers presented at international conferences for the full sample (b=.089) and for men (b=.115). As with the association between presentations at international conferences and an increase in gender diversity, the direction of this relationship is likely circular. On the one hand, it may be that more geographically dispersed ties is useful for acquiring information and funding related to

attendance at international conferences. On the other hand, it may be that it is the conference attendance itself which leads to the geographic diversity of ties. In all likelihood, the relationship flows in both directions, attendance at international conferences increases the likelihood that one will establish ties located in a variety of different countries, which in turn may increase the probability of future international conference attendance.

Turning to the relationship between international paper presentations and network size, an interesting relationship emerges. For the full sample (-.201) and for men (-.269), an increase in network size is negatively associated with the number of papers presented at international conferences. Typically, larger networks are assumed to be wider ranging, which in turn leads to access to larger variety of resources. In this context, one might predict that possessing wider ranging networks (in terms of size), would lead to positive instrumental outcomes, such as conference presentation. After controlling for other factors, this trend does not emerge. Having more professional contacts actually leads to a fewer number of articles presented at international conferences. This finding may again, be related to effort. Increasing the number of important ties requires more effort. One of the most basic tenants of interaction is reciprocity. More contacts may equate to more obligations which constrains ones ability to produce but only in a particular context. As I noted before, more ties over time leads to more output for women in terms of papers written. This suggests what one might intuitively infer; international productivity requires a greater expenditure of time, money, and energy which detracts from one's ability to place his/her efforts in other areas of professional activity, such as maintaining contacts. Writing papers, on the other hand, while time consuming in its own right, benefits from more ties because of the exchange of ideas and perhaps this is even a reflection of collaboration between researchers.

Finally, measures of human capital also seem to be fairly good predictors of research output. For the full sample, having a PhD is significantly and positively related to the number of papers written (b=.080) and the number of papers presented at national (b=.112) and international conferences (b=.177). Researchers who have invested in the acquisition of a PhD are more productive by wave two of the study than those who have not made the same investment. Men seem particularly adept at turning their human capital into research output as they present more papers at national (b=.165) and international conferences (b=.181). Possession of a PhD, furthermore, has a significantly different effect based on gender for the number of papers presented nationally.

Although context has emerged as one of the strongest and most consistent predictors in the two previous chapters, for these measures of output it does not seem to be as strongly associated with two exceptions. Being from Kenya is negatively associated with the number of papers written for the full sample (b=-.114) and for men (b=-.125), while being from Kerala is positively associated with the number of papers presented at national conferences and workshops for the full sample (b=.122) and for women (b=.401). The finding in regard to Kerala is consistent with research conducted in this area previously. Duque et. al. (2005) and Ynalvez et. al. (2005), for instance, both note a more productive domestic research environment in Kerala as compared to African countries. Although this is only one measure of productivity, it does offer preliminary support for this previous research.

In general, localism is not a significant predictor of research output in these three areas. However, women who travel more outside of their respective locations present significantly fewer papers nationally (b=-.106). This effect is significantly different for men and women.

The only measures of family structure to emerge as significant predictors of research output are marital status and spouse's occupation. Women whose spouses are also researchers write more papers, regardless of publication status, than do women who are either not married or whose spouses are engaged in some other occupation (b=.157). Although not significantly related to the number of papers written, the effect of having children is significantly different for men and women. Women with children write fewer papers while men with children write more. Interestingly, being married is negatively associated with the number of papers presented nationally but only for the full sample (b=-.172) and men (b=-.329), but men with children actually present *more* papers at national conferences (b=.051).

This latter finding, as well as the differential effect of children on the number of papers written by men and women may have something to do with marital status. As reported in table 4.2, approximately 95% of men are married across the two waves (and approximately 85% of women), and 20% of these men have wives who stay at home (no women report such a spousal status). Children, particularly young children, require a significant expenditure of time and energy. A spouse, who stays at home, thus provides male researchers with perhaps more opportunity to travel to national conferences for presentations and permits them more time to stay at the office working on papers. Women with children, lacking a stay at home spouse, do not have the same opportunity.

Predictors of Research Productivity—Output in Non-Mainstream Venues

In the previous chapter, gender and technological behavior changes were unrelated to the first step in the research process, ties to other researchers emerged as a fairly consistent predictor for productivity. Do differences between men and women and increases in technology use impact research output in terms of reports and bulletins? Generally speaking, the answer is

again, ‘no’. In addition, unlike in the previous chapter, measures of professional network structure also appear to not be significant predictors of time two productivity on these measures.

In the previous five years (between 2000 and 2005), regardless of gender, researchers in Ghana, Kenya, and Kerala report approximately the same number of reports and bulletins written. Furthermore, none of the measures of change in technological behavior are significantly related to output in these venues. The only measure approximating technology use to emerge as significant is an increase in comfort using the Internet. As with the number of papers presented in the national context, respondents who are more comfortable using the Internet, also produce more in terms of the number of reports. This finding holds for the full sample (b=.037) and for men (b=.062). The effect of this coefficient, furthermore, is significantly different for men and women. The only network variable associated with time two productivity is an increase in geographic diversity. Men reporting more geographically diverse professional ties, write significantly fewer bulletins for extension (b=-.127). Generally speaking, geographic diversity has been unrelated to the outcomes measured so far, and when it is associated, the direction of the relationship has been negative. Outside of international productivity in the form of presentations, increasing the geographic diversity of one’s ties appears to lead to <u>less</u> productivity, not <u>more</u>.

As with the number of papers written, being married to a researcher is significantly associated with the number of reports produced for the full sample (b=.135) and for men (b=.200). By far, though, the strongest predictor of the number of reports written is sector of employment. Working in the research sector is significantly and positively associated with the number of reports written for the full sample (b=.348) and the disaggregated sample (b=.385 for men and b=.261 for women). Previous research on productivity accounting for sector of

Table 7.4: OLS Regression Analysis for the Number of Reports and Bulletins for Extension Written by 2005

	Number of reports 2005 (N=334)				Number of bulletins for extension 2005 (N=304)			
Independent and Control Variables	Full Sample	Males[1]	Females	Z	Full Sample	Males	Females	Z
Constant	.279	.090	.617	ns	.081	.035	.210	ns
	(.186)	(.234)	(.411)		(.164)	(.235)	(.344)	
Gender (1=male)	.045	---	---		.037	---	---	
	(.060)	---	---		(.048)	---	---	
Age (years)	.000	.002	-.002	ns	.002	.003	.001	ns
	(.004)	(.004)	(.009)		(.003)	(.004)	(.007)	
Education (1=PhD)	.046	.078	-.077	ns	.000	-.013	.043	ns
	(.056)	(.065)	(.116)		(.046)	(.056)	(.089)	
Family Structure								
Married (1=yes)	-.069	-.030	-.282	ns	-.118	-.089	-.080	ns
	(.095)	(.135)	(.163)		(.083)	(.147)	(.126)	
Number of children	.007	.026	-.047	ns	.020	.014	.037	ns
	(.021)	(.025)	(.045)		(.018)	(.021)	(.038)	
Spouse a researcher (1=yes)	.135*	.200*	.152	ns	.058	.074	-.001	ns
	(.069)	(.084)	(.134)		(.054)	(.068)	(.101)	
Localism								
Increase in # years abroad	-.016	-.003	-.135**	2.43	-.023	-.027	-.024	ns
	(.019)	(.021)	(.050)		(.015)	(.018)	(.038)	
Context								
Kerala	-.108	-.117	.096	ns	-.041	-.033	-.093	ns
	(.071)	(.076)	(.231)		(.062)	(.069)	(.214)	
Kenya	.096	.092	.341	ns	-.051	-.062	-.059	ns
	(.067)	(.072)	(.214)		(.062)	(.070)	(.207)	
Sector	.348***	.385***	.261*	ns	.052	.049	.021	ns
	(.052)	(.060)	(.117)		(.041)	(.050)	(.082)	
Technology Antecedents								
PC in personal office	.074	.068	.111	ns	.025	.036	-.068	ns
(Both waves)	(.053)	(.058)	(.146)		(.044)	(.050)	(.117)	
Increase in Comfort using Internet	.037*	.062**	-.023	2.10	.026	.030	.008	ns
	(.018)	(.022)	(.034)		(.014)	(.019)	(.025)	
Technological Behavior								
Increase in extent of email use	.007	.005	-.006	ns	.019	.021	.025	ns
	(.014)	(.016)	(.032)		(.011)	(.013)	(.024)	
Increase in intensity of email use	-.018	-.008	-.018	ns	-.004	-.005	-.021	ns
	(.025)	(.030)	(.051)		(.020)	(.026)	(.038)	
Professional Contacts								
Increase in network size	.061	.057	-.094	ns	.082	.122	-.030	ns
	(.111)	(.129)	(.252)		(.092)	(.113)	(.196)	
Gender diversity (time two)	.039	-.018	.185	ns	.044	.100	-.066	ns
	(.059)	(.070)	(.113)		(.048)	(.062)	(.088)	
Increase in geographic diversity	-.013	-.024	.097	ns	-.075	-.127*	.042	ns
	(.054)	(.063)	(.113)		(.044)	(.055)	(.087)	
Time lag	.085***	.078**	.131**	ns	.115***	.109***	.134	ns
	(.021)	(.025)	(.044)		(.019)	(.023)	(.044)	
R2	.305	.302	.459		.177	.182	.247	

[1]***p<.001; **p<.01; *p<.05

employment identified the university setting as a context in which researchers tended to be much more productive (McGinnis et. al. 1982). The measures of productivity, however, were typically acquired through citation counts in standard academic journals. Within research centers, however, report writing comprises a significant portion of the research process. It is not surprising, then, that being employed in this sector is associated with significantly more output in this venue. In fact, comparing the bivariate relationship between research institutes and universities and the number of reports written reveals a modal value of 10 for the full sample of respondents employed in a research institute. For the full sample of respondents employed in a university, the modal value on reports is 0 (data not shown).

The last measure revealing an association to productivity is localism. As with the previous section, an increase in the number of years spent traveling is negatively associated with the number of reports written between 2000 and 2005 (b=-.135). And again, this outcome is only significant for women. Women who report traveling more in developed countries, report fewer publications in this venue. This could be the effect of numbers (recall from table 4.1, women comprise a minority of workers in this sector to begin). However, comparing the women who are employed in this sector to the men employed in this sector reveals that they write *more* reports than men (data not shown). As before, I suggest that the effect of travel on the number of reports and papers at national workshops reflects a pattern in which a more foreign orientation to one's career occurs to the detriment of one's local orientation. The effect, furthermore, is significantly different for men and women.

Predictors of Research Productivity—Output in Scholarly Venues

In the final table, I present the research output reported in venues generally considered standard locations (indeed, perhaps the most visible locations for the research community at

large) for publishing scientific findings: domestic and foreign journals and chapters in books. Up to this point, gender has not been significantly related to research output, a finding that is generally consistent with the results for the bivariate relationship between gender and productivity examined in table 7.1. From table 7.1, two variables did emerge as statistically different by gender and across both waves: the number of articles published in foreign venues. As with the bivariate relationship, gender emerges as a significant predictor of foreign productivity in table 7.5. In fact, after controlling for other factors, it is the only measure of research output for which gender significantly affects outcomes. Female researchers are significantly less likely than male researchers to publish in foreign journals (b=.116). Regardless of gender, men and women publish approximately the same number of articles in national journals and chapters in books.

How do changes in the structure of professional networks and changes in access to and use of ICTs relate to productivity? For female researchers as a group, none of the professional contact or technology measures are significantly related to productivity in time two, and this pattern holds across all three measures of research output. In addition, professional ties are unrelated to publications in foreign journals for both the aggregated and disaggregated samples. Possessing broader ranging networks (in terms of size and diversity), does not result in significant increases in foreign productivity. Instead, professional network structure is more consistently related to the number of articles published in national journals and the number of chapters published in books, but the measures that predict outcomes in these venues are distinctly different. Reporting an increase in the gender diversity within one's professional networks is associated with more publications in national journals, but it is unrelated to the number of chapters published in books. For the aggregated sample, those who report a more

Table 7.5: OLS Regression Results for the Number of Articles Published in Foreign and National Journals and the Number of Chapters Published in Books by 2005

	Number of articles in foreign journals 2005 (N=316)				Number of articles in national journals 2005 (N=326)				Number of chapters in books 2005 (N=301)			
Independent and Control Variables	Full Sample	Males[1]	Females	Z	Full Sample	Males	Females	Z	Full Sample	Males	Females	Z
Constant	.233	.383	.320	ns	.260	.388	-.500	2.02	.271*	.336*	-.109	ns
	(.161)	(.223)	(.290)		(.163)	(.203)	(.389)		(.127)	(.162)	(.344)	
Gender (1=male)	.116*	---	---		.000	---	---		-.016	---	---	
	(.048)	---	---		(.049)	---	---		(.036)	---	---	
Age (years)	-.003	-.003	-.002	ns	-.001	-.005	.012	ns	-.002	-.003	.003	ns
	(.003)	(.004)	(.005)		(.003)	(.004)	(.008)		(.002)	(.003)	(.006)	
Education (1=PhD)	.095*	.103	.065	ns	.098*	.107*	.074	ns	.139***	.166***	.043	ns
	(.048)	(.060)	(.074)		(.047)	(.051)	(.114)		(.034)	(.039)	(.078)	
Family Structure												
Married (1=yes)	.011	.012	.082	ns	-.030	.019	-.130	ns	-.044	-.112	-.049	ns
	(.079)	(.127)	(.108)		(.088)	(.132)	(.155)		(.063)	(.096)	(.117)	
Number of children	-.014	-.024	.005	ns	.019	.026	.011	ns	.012	.024	-.022	ns
	(.018)	(.022)	(.031)		(.018)	(.020)	(.046)		(.013)	(.015)	(.034)	
Spouse a researcher (1=yes)	.039	.008	.089	ns	-.032	-.045	-.005	ns	-.083*	-.088	-.044	ns
	(.054)	(.071)	(.082)		(.056)	(.065)	(.126)		(.041)	(.049)	(.089)	
Localism												
Increase in # years abroad	.039**	.043*	.021	ns	-.013	-.006	-.075	ns	-.015	-.021	-.021	ns
	(.015)	(.018)	(.031)		(.016)	(.016)	(.046)		(.011)	(.012)	(.033)	
Context												
Kerala	.066	.075	-.211	ns	.092	.087	.380	ns	-.038	-.049	.266	ns
	(.062)	(.071)	(.202)		(.060)	(.061)	(.247)		(.050)	(.051)	(.248)	
Kenya	.091	.097	-.150	ns	-.088	-.132*	.351	-2.06	-.107*	-.140**	.303	ns
	(.059)	(.068)	(.196)		(.057)	(.059)	(.227)		(.049)	(.051)	(.241)	
Sector	-.054	-.060	-.049	ns	-.102*	-.124**	-.024	ns	-.022	-.027	-.021	ns
	(.040)	(.051)	(.068)		(.041)	(.046)	(.103)		(.031)	(.035)	(.072)	
Technology Antecedents												
PC in personal office	.104*	.099	.128	ns	.065	.071	-.042	ns	.089**	.102**	.022	ns
(Both waves)	(.044)	(.051)	(.098)		(.045)	(.046)	(.151)		(.033)	(.035)	(.106)	
Increase in Comfort using Internet	.007	.004	.008	ns	.034*	.030	.027	ns	.022*	.035**	.001	ns
	(.014)	(.019)	(.021)		(.015)	(.017)	(.033)		(.010)	(.013)	(.022)	
Technological Behavior												
Increase in extent of email use	.023*	.028*	-.002	ns	.015	.024*	-.028	ns	.003	.001	.008	ns
	(.011)	(.013)	(.019)		(.011)	(.012)	(.030)		(.008)	(.009)	(.021)	
Increase in intensity of email use	-.044*	-.064*	.012	ns	-.009	-.011	.023	ns	-.042**	-.056**	-.014	ns
	(.020)	(.026)	(.031)		(.021)	(.023)	(.048)		(.015)	(.018)	(.034)	
Professional Contacts												
Increase in network size	-.031	-.042	.001	ns	.018	.013	.272	ns	.121	.156*	.119	ns
	(.087)	(.109)	(.156)		(.091)	(.099)	(.232)		(.066)	(.076)	(.170)	
Gender diversity (time two)	-.065	-.093	-.003	ns	.098*	.067	.189	ns	.028	.035	.015	ns
	(.047)	(.062)	(.069)		(.048)	(.055)	(.103)		(.036)	(.043)	(.073)	
Increase in geographic diversity	.023	-.006	.051	ns	-.006	-.035	.084	ns	-.053	-.078*	.010	ns
	(.044)	(.056)	(.069)		(.044)	(.049)	(.105)		(.033)	(.039)	(.073)	
Time lag	.189***	.185***	.181***	ns	.106***	.117***	.081	ns	.117***	.188***	.121*	ns
	(.018)	(.021)	(.034)		(.018)	(.020)	(.044)		(.018)	(.020)	(.047)	
R2	.435	.411	.489		.305	.368	.307		.296	.382	.184	

[1] ***p<.001; **p<.01; *p<.05

diverse gender composition in their professional network structure from time one to time two also publish more in domestic journals (b=.098). No relationship emerges between this variable and the disaggregated sample, however.

None of the professional contact measures emerge as significant predictors of productivity in edited volumes for the full sample, but male researchers who report an increase in network size are also more likely to publish chapters in books (b=.156). Increasing the number of professional ties maintained, leads to more output in edited volumes. As Miller et. al. (2006) suggest in there article on gender differences in productivity, professional ties should be related to publications in this venue, as book chapters are usually done through invitations. An increase in the geographic diversity of one's ties (i.e. reporting ties located in a variety of locations), however, is negatively associated with the number of chapters published in edited volumes. Men reporting an increase in the geographic diversity of their professional networks, publish fewer chapters in books (b=-.078).

A number of the technology measures, for both the full sample and male researchers, emerge as significantly related to scientific output. For instance, for the aggregated sample having a PC in one's personal office in both waves of the study is positively associated with foreign productivity (b=.104) and with the number of chapters published in books (b=.089). The latter finding also holds for men. Men with easier access to the work PC across both waves of the study are more productive in edited volumes (b=.102). Increases in the diversity or extent of activities engaged in while using email is positively related to research outcomes in foreign and domestic journals, while increases in the intensity of email use, is negatively related to foreign productivity and book chapters.

In other words, researchers who use email for a wider number of purposes over time are indeed more productive in foreign (b=.023 for the full sample and b=.028 for men) and domestic journals (b=.024 for men). Those using email more intensely in terms of the number of hours of email use, however, are less productive in foreign journals (b=-.044 for the full sample and b=-.064 for men) and edited volumes (b=-.042 for the full sample and b=-.056 for men). Researchers using email more intensely, those who report more hours spent using email over time, actually produce fewer articles in foreign journals, again suggesting that perhaps there is a zero-sum relationship regarding time spent using technology and other outcomes.

The only technology measure not to emerge as a significant predictor of foreign productivity for the full sample is in relation to increases in comfort using the Internet. Instead, this measure is a significant predictor of the number of articles published in domestic journals and the number of chapters published in edited volumes. For the full sample, respondents who are more comfortable using the Internet are also more productive in domestic journals (b=.034). Those respondents whose comfort level using the Internet has increased over time are more likely to publish chapters in books for both the full sample (b=.022) and for men (b=.035).

In terms of the control variables, the most consistent predictor of research productivity in these three venues is the possession of the PhD. In all three of the full models, having a PhD is significantly and positively associated with publishing in foreign (b=.095) and domestic journals (b=.098) and chapters in edited volumes (b=.139). When disaggregated by gender, however, the effect of having a PhD is only significant for male researchers and then only in two venues. Male researchers possessing a PhD are more likely to publish in domestic journals (b=.107) and to write book chapters (b=.166) than are males not possessing the PhD.

Interestingly, family structure is relatively unrelated to productivity in these three venues. As stated in chapter four, family structure is one of the most examined predictors of gender differential career outcomes. Although the nature (in terms of the direction) of this relationship, even in a more developed context, is somewhat inconclusive, family structure is nearly always associated in some way. In these three less developed countries, marked by systems of patrifocality, family structure is relatively unrelated to measures of productivity. Being married, having children, and having a spouse who is also a researcher are not significantly related to the number of publications in any of the three venues examined in table 7.5 with one exception. The only significant predictor of productivity for the measures of family structure is for the full sample. A researcher who is married to a man or a woman who is also engaged in some sort of research pursuit are less productive in edited volumes (b=-.083). One might intuitively expect a positive relationship as marriage to a spouse in the same or similar scientific field not only provides emotional support as a spouse but also professional support. Indeed in the previous two sections, when this measure was significant, it was positively related to outcomes.

In terms of context, Kenya emerges as a fairly consistent and negative predictor of productivity in both domestic journals and book chapters. Researchers, specifically male researchers, from Kenya tend to publish less in national journals (b=-.132) and in edited volumes (b=-.140 for men and b=-.107 for the full sample) than do researchers in other locations. The negative relationship between productivity in national journals and being from Kenya is significantly different for males and females. In addition to Kenya, being employed in a research institute is negatively associated with productivity in national journals for both the full sample (b=-.102) and for men (b=-.124). This finding is likely related to the structural expectations placed on researchers employed within academia vs. those employed outside of academia.

Stated simply, researchers in universities are expected to publish more, in these venues particularly.

In the previous two subsections measuring the association between research output and decreases in localism (i.e. increases in travel) has revealed that travel is largely unrelated to productivity, but when it is related, the association is *negative.* I argued that this effect is due, at least in part, to international travel taking the focus of researchers away from productivity at the national level. Further support for this argument is found in table 7.5. According to the first column, measuring the number of articles published in foreign journals between the period of 2000-2005, spending more years outside of Ghana, Kenya, and Kerala is positively associated with productivity in this venue for both the full sample (b=.039) and for males (b=.043). Through travel outside of the immediate environment, researchers acquire a set of skills and knowledge that may be more difficult to acquire within the home environment. These skills may then translate into easier maneuverability through the publication process in foreign journals. But I think it is important to reiterate that this set of skills does not appear to translate beyond research output in international venues.

Summary

In sum, productivity seems to be most tied to human capital. Researchers with a PhD are more productive in mainstream scholarly venues such as book chapters and foreign and domestic journals. Possession of a PhD is associated both with the type of employment one acquires after graduate school, which may structure productivity, but it is also associated with developing a set of skills and a knowledge set which is conducive to increasing research output. No consistent relationship emerged between family structure, age, gender, and context (although when significant, Kenyans tended to be less productive than researchers from other locations). Outside

of publishing in foreign journals, no gender differences emerge between men and women. Males are more likely to report publishing in foreign journals than are females. Furthermore, neither the network measures nor the technological behavior measures are consistently related to any of the outcome measures examined here. Although they emerge as significant predictors of productivity on a number of the dependent variables, it is often in unexpected ways.

CHAPTER 8: SUMMARY AND CONCLUSIONS

This research takes an important step towards understanding the complex relationship between new technologies and social change. I began this dissertation with three questions regarding gender and science in less developed areas: 1) what gender differences emerge in access to and use of technological resources over time; 2) how do these gender differences in access to and use of technologies relate to gender differences in the structure and composition of professional networks; and 3) how do such changes relate to gender disparities in career outcomes in terms of professional productivity in scientific journals.

To answer these questions, I situated the analysis at the intersection of globalization and development studies, science and technology studies, gender studies, and social network analysis. I argued that an examination of the dynamic interplay between the structural and agentic dimensions of social life is needed in order to move away from the technological determinism dominating the discourse coming out of the development community. The exercise of power through access to resources, the production of knowledge in scientific journals, and the nature of action are simultaneously constrained and enabled by place, time, and identity. In order to address these issues, I employed a network approach because such an approach provides an alternative to the traditional perspectives still dominating the discourse of the development community. Social network analysis provides a way of examining the way in which personal and professional relationships structure the professional outcomes of scientists in less developed areas.

Furthermore, rather than view the relationship between ICTs and scientific advancement as unproblematic, I suggested that the socially constructed nature of gender, science, and technology need to be accounted for. By situating the discussion within the reagency

perspective, this dissertation addressed why, in spite of the optimistic projections coming out of the development community, ICTs have yet to produce dramatic changes in the research careers of female scientists in less developed countries. An argument could be made that there simply has not been enough time for the diffusion of the technology to make any significant, empirical changes. Perhaps the span between the first and second waves of this study represents a lag period in which the technology has spread but its full incorporation into the research career has yet to occur.

On the other hand, while changes in communication technologies may be associated with changes in inequality in resource distribution, the lagged effect of gender status beliefs following such social structural changes means that new inequalities will likely emerge to replace the old. The 'promises' and 'threats' of ICT, in other words, are constrained by social structure, not separate from it. At the same time that ICT may be used by people to create new opportunities, it also creates "new forms of domination and competition" (Fuchs 2008: 7). Indeed, the notion of gendered reagency put forth here, however, suggests that, while one cannot entirely rule out this scenario, the interaction between ICTs and its users do not behave in predictable ways. Due to contextual and agentic factors, the way in which the Internet and email are used within the research career will vary across countries and within them based on the demographic characteristics of the individuals using the technologies.

In the context of developing world science, aid, resources, and technologies are transferred to resource poor environments marked largely by patrifocal gender relationships. When agents from other, often more developed, locations enter such an atmosphere, the manner in which the focal actors of development activity (i.e. those who are the intended recipients of aid or other resources, for instance), are not merely adopting resources and implementing them in

ways that correspond with the stated goals of the development actor or organization. Instead, they are incorporating such resources into their environments in ways that have nothing to do with the intentions of development actors from the United States and Western Europe.

Although Shrum (2005) suggested that all development projects are reagentive in the sense that they create a reaction from the people at whom they are targeted, he also proposed that the Internet may be different than past projects due to the reconfiguration of space and time created by use of the technology. The Internet, email, and even mobile phones do not necessitate co-presence in order for interactions to occur. Individuals are able to connect with one another regardless of location as long as the prerequisite hardware and infrastructure are in place to support communication. In this way, space is altered by new ICTs. Not only is space transformed, however, but so too is time. Actors from more developed areas and those from less developed areas need 'simply' log on to the Internet at their convenience, regardless of time differentials. For these reasons, the Internet, theoretically, should make long-distance professional interactions easier to engage in and maintain.

However, the assumptions of simplicity and ease of interaction must be critically examined. Not only do infrastructural, hardware, software, and connectivity constraints limit the ease and simplicity of interactions, but so too does the nature of relationships. Relationships, professional or otherwise, require effort, good will, time, trust, and patience in order to maintain and develop. Without co-presence (even if such co-presence is intermittent), instead of greater connectivity to other researchers in the long run, we may see a decaying effect. With the initial diffusion and adoption of technologies (assuming that occurs), contacts with others may appear to increase. Over time, however, with the flow of everyday activities continuing as usual in both core and peripheral countries, these ties may diminish due to the difficulties associated with

long-distance relationships. Such difficulties, furthermore, are magnified when one considers the context in which this study occurs. Researchers in environments marked by a greater degree of resources may find that their long distance connections diminish overtime, this even with easy access to fast and reliable technology. This situation is likely to be exacerbated for relationships moving across core and peripheral boundaries, where a person may wait days or even weeks to hear from a colleague in Kenya due to connectivity limitations.

In addition, issues beyond structural constraints also thrust the overly optimistic accounts of ICTs and development into question, particularly when one considers gender differences. Interacting with environments already lacking in resources and funding, largely unconscious gender schemas influence researcher's interaction patters, adoption and use of technologies, and career outcomes. Men and women's identities, in addition to gendered norms of behavior and gendered expectations of competency and influence, suggest that the gendered differences in the research career will likely continue to exist in the Internet age. Men and women carry their identities and expectations into cyberspace. They do not disappear entirely. The way they operate may look marginally different from past gendered inequalities, but they do not disappear altogether simply because one possesses a good Internet connection.

In order to more fully investigate these arguments I separated the analysis into four substantive chapters. In the first results chapter, I examined the bivariate relationship between gender and the five dimensions most consistently identified in the literature as significant predictors of gender differences in career outcomes: 1) family structure; 2) possession of human capital; 3) localism expressed through travel experiences outside of the immediate environment; 4) contextual factors; and 5) technological antecedents. In the second results chapter I examined the predictors of access to and use of ICTs in order to determine whether or not gender emerged

as a significant variable after controlling for other factors. In the third results chapter, I moved to examining the predictors of network structure and finally, in the fourth results chapter, I examined the predictors of research productivity.

Antecedent Factors Predicting Gender Differences

Consistent with expectations, the majority of the women in this sample of researchers are employed in Kerala, a context in which historical and cultural gender relationships have created less rigid expectations for men and women's behavior and allowed for more flexible educational and occupational gender roles than in Kenya or Ghana. Although men and women are more likely to be employed in academia, women comprise a substantially larger percentage of the academic sample as compared to the national research sector sample.

Many of the gender differences in Ghana, Kenya, and Kerala are consistent with the gender differences in more developed research systems. As might be expected based on the findings of researchers in the United States and Western Europe, women are most likely to be working in the life sciences and least likely to be working in physics or engineering. Women are also less likely to be married, and they have fewer children than men. When they do marry, women marry another researcher at a greater rate, while slightly less than a quarter of all men report a spouse who stays at home. Gender differences in family structure is one of the most examined dimensions of scientific outcomes. Women, as the kin-keepers in most cultures, including the three examined here, appear to postpone family formation. One may assume that this tendency is due in part to the constraints such roles might place on women's career participation in comparison to their male counterparts.

As with women in more developed areas, female researchers in Ghana, Kenya, and Kerala are investing more time, money, and effort into attaining higher degrees. The gender

disparities in the possession of human capital in the form of a PhD or masters degree have all but disappeared. In fact, there seems to be some indication that women are pulling ahead of their male counterparts in terms of possessing the PhD. Consistent with previous research in this area, women are more locally oriented than their male counterparts regardless of the wave considered. Regardless of sex, however, this sample of researchers is continuing to travel over time, spending more years in a developed country for any reason.

Finally, two precursors to technological use identified as being significant predictors of whether or not women actually use a technology (which may in turn impact other career outcomes) were examined in chapter four. The first approximates the ease associated with using a technology, and the second measures respondent's self-reported comfort with the Internet. Significant gender differences do emerge in this regard in the three countries examined here, particularly in the context of ease of access and use. While women are significantly less likely to report possessing a PC in their office in both waves, they are as comfortable using the Internet as men by the second wave. One's comfort using a technology, something that is likely associated with skill and years of use, is not differentiated by gender, but the possession of a PC in a place where on might use it easily, frequently, and without interruption is associated with gender. This may in part be a reflection of women's using a technology in alternate locations; building a skill set and comfort level outside of the workplace.

In spite of the fact that both men and women are experiencing significant changes over time on many of the dimensions examined in chapter four, the gender differences found in wave one largely persist. In other words, both groups are experiencing the same degree of changes in family structure, human capital, technological antecedents, and localism so that the similarities

and differences are largely the same over time. How then, do these factors relate to gendered access to ICTs, differential network structures, and research outcomes?

Gender and Access to and Use of ICTs

The next issue I examined related to the gender disparities in personal computer, email, and Internet use. Expounding on Katz and Rice's (2000) assertion that one of the core issues in ICT debates is access, I examined access to various technologies. Because access in and of itself is no longer the primary determinant of the digital divide, I broadened the approach and examined various issues related to use of ICTs. According to the bivariate results, gender disparities in email and Web use persist over time with men being more diverse and intense users of technology than women. However, women start out as less technologically oriented. As such, it isn't surprising to find that they continue to be less technologically oriented by wave two. The more interesting trend (one that emerges from examining the bivariate relationships) is that both men and women are becoming more diverse and intense users over time. The gender differences emerging in the bivariate results largely remain in the multivariate analysis supporting many of the hypotheses I presented in chapter five.

Specifically, I hypothesized that 1) male researchers would be more likely to report consistent, long-term access to a personal computer than females; 2) men would be more likely to report consistent, long-term email access than females; 3) men would be more likely to report consistent, long-term Web use than females; and 4) men would be more likely to identify as long-term users of email than females. Three of the first four hypotheses were supported. The only chapter five hypothesis not supported concerns ready access to a personal computer within the workplace. After controlling for other factors, men and women are equally likely to report consistent long-term access to a personal computer in the workplace. In other words, personal

Table 8.1: Summary of Hypothesis and Findings	
Hypothesis	Results
Chapter 5	*Chapter 5*
• Men will be more likely to report consistent, long-term access to a personal computer	• Not supported
• Men will be more likely to report consistent, long-term email access	• Supported
• Men will be more likely to report consistent, long-term Web use	• Supported
• Men will be more likely to identify as long-term users of email	• Supported
• Men will be earlier adopters of the Web	• Not supported
• Men will be earlier adopters of email	• Not supported
• Men will use the Web more intensely	• Supported
• Men will use email more intensely	• Supported
• Men will use the Web more extensively	• Supported
• Men will use email more extensively	• Not supported
Chapter 6	*Chapter 6*
• Respondents using email more extensively over time will report larger professional networks	• Supported for aggregated sample
• Respondents using email more intensely over time will report larger professional networks	• Not supported
• Respondents using email more extensively over time would report more geographically diverse professional networks	• Not supported
• Respondents using email more intensely over time would report more geographically diverse professional networks	• Supported for women
• Women will report smaller professional networks than	• Supported
• Women will have less diverse professional networks based on geographic location	• Supported
• Women will report a larger proportion of domestic contacts	• Not supported
• Women will report a smaller proportion of foreign contacts	• Supported for intermediate distant ties
• Women will have more diverse professional networks based on gender	• Supported
• Women's professional networks will have a lower proportion of male contacts	• Supported
Chapter 7	*Chapter 7*
• Respondents with larger professional networks will produce more in foreign venues	• Not supported
• Respondents with larger professional networks will produce more in domestic venues	• Not supported
• Respondents with more geographically diverse professional networks will produce more in foreign venues	• Not supported
• Respondents with more geographically diverse professional networks will produce more in domestic venues	• Not supported
• Respondents with more gender diverse professional networks will produce more in foreign venues	• Not supported
• Respondents with more gender diverse professional networks will produce more in domestic venues	• Supported for the full sample
• Respondents using email for a wider variety of reasons over time will produce more in foreign venues	• Supported for the full sample and men
• Respondents using email for a wider variety of reasons over time will produce more in domestic venues	• Supported for men
• Respondents using email more intensely over time will produce more in foreign venues	• Not supported
• Respondents using email more intensely over time will produce more in domestic venues	• Not supported
• Women will produce less in foreign journals	• Supported
• Women will produce more in domestic journals	• Not supported

computers are widely available in the workplace within these three locations. Even if a researcher does not have 'ready access' within a private office, he/she is able to access a computer from a shared computer room or lab somewhere on campus or on the grounds of the institute.

Distinctly different results emerged for men and women in regards to connectivity, however. Men were more likely to report having consistent, long-term access to email, and they were more likely to identify as email and Web users in both periods. I argued in chapter five, that to an extent, access to technology and identification as a user of technology are both subjective measures. Ready access and use mean different things. To me, it may mean the ability to access email in both my home office and my workplace. In a less resource rich environment, it may indicate a five minute walk to an Internet café. The finding that men consistently report access suggests that they experience a distinctly different technological environment than do women. Even without connectivity, PCs are useful tools, but the question in the context of the digital divide is whether or not men and women in less developed areas are equally *connected.* According to these results, no, they are not. Over the lifetime, men are more connected than women.

Next, I hypothesized that 5) men would be earlier adopters of the Web than women; and 6) they would be earlier adopters of email than women. Within a more developed context and based on the general population, men are consistently earlier adopters of most technologies. Interestingly, neither of these hypotheses is supported in the multivariate analysis. Men and women have been using email and the Web for approximately the same number of years, suggesting that among researchers in less developed areas, men are not earlier adopters of technology. Researchers simply have a different relationship to technology. Men and women

have a vested interest in adopting early as their scientific careers stand to benefit from adoption. Given the appropriate infrastructure and hardware, men and women are equally likely to be early adopters of the Web and email. It stands to reason that the earlier one adopts a given technology, the more time he/she has to develop the skills, motivation, and comfort level, leading to, not only continued use, but beneficial outcomes from use.

Finally, I hypothesized that 7) men would use the Web more intensely than females; 8) they would use email more intensely than females; 9) they would use the Web more extensively than females; and 10) they would use email more extensively than females. All but one of the hypotheses is supported. Men use email and the Web more intensely than women, and they use the Web for a wider variety of reasons than women do. The only hypothesis not supported is in relation to the extent of email use. Gender is not a significant predictor of the types of activities men and women engage in using email. In other words, while male and female researchers in less developed areas began using email and the Web at approximately the same time, there are distinct gender differences in the types of users they become.

Men's web and email use tends to be more intense, suggesting they spend longer periods during the course of a week using the technology. Such intensity, however, may not translate into instrumental outcomes in the form of productivity as I suggest below. The lack of significant differences in email use may actually be consistent with research on gender differences in email use coming out of the United States and Canada (Boneva and Kraut 2003; Howard, Rainie, and Jones 2002). According to this research, women tend to use the Internet for communication purposes, primarily through email, more than men do. This may, in fact, be why there are no gender differences in the extent of email use. Men do, however, use the Web for a wider variety of reasons from creating a web page, to publishing a paper, or simply accessing an

electronic journal, men spend more time online engaged in more activities. More extensive use may lead to distinctly different career outcomes, in terms of network structure and productivity, stratified along gender lines.

Gender, ICTs, and Professional Network Integration

In chapter six, I addressed issues related to gender, ICTs and integration within scientific, professional networks. I began this chapter with two questions. The first considered the relationship between ICTs and professional network structure. Specifically, I asked, do changes an email behavior result in a greater or less degree of social integration within professional scientific networks? A number of dimensions related to network range were examined including absolute network size, gender and geographic diversity, the proportion of male contacts, and the proportion of contacts based on geographic locations (i.e. the proportion of ties within Ghana, Kenya, and Kerala, the proportion of contacts within Africa and India, and the proportion of contacts within the scientific core of the United States and Europe). I hypothesized: 1) respondents using email more extensively over time would report larger professional networks; 2) those using email more intensely over time would report larger professional networks; 3) those using email more extensively over time would report more geographically diverse professional networks; and 4) those using email more intensely over time would report more geographically diverse professional networks.

Examining the results from chapter five makes it clear that ICTs have diffused rapidly in the last three to five year period within the research systems of these three countries. The relatively large increases in access to and use of ICTs reported by both male and female researchers, however, are not significantly impacting the network structure of developing world scientists. If anything, the bivariate analysis might lead one to conclude that increased

technology diffusion is actually leading to greater professional isolation, particularly for female researchers. At the same time that email and web access are being reported by a significantly larger percentage of men and women, women's networks are actually *decreasing* over time. Of course, with a bivariate analysis it is impossible to tie this trend directly to ICTs, but it is an interesting phenomenon.

The bivariate relationship, while interesting, is not enough to draw any firm conclusions regarding gender differences in network structure associated with the diffusion of ICTs. For that, I turn to the multivariate analysis. According to the results presented in tables 6.3 and 6.4, changes in technological behavior over the relatively short period examined here are not associated with the majority of the network measures. Although I didn't develop hypotheses regarding the proportion of ties located in the different geographic areas, it is clear that after controlling for other factors, increases in email use are not related to the proportion of ties at nearly all of the spaces examined, with one exception. Women reporting an increase in the extent of email use are indeed reporting a larger proportion of ties at the core. To reiterate, this is the only measure explicitly related to the proportion of one's network at various locations.

Turning to the hypotheses provides a little more support for the notion that changes in technological behavior might lead less developed country researchers to be more integrated. Two of the four hypotheses were supported regarding technology behavior and network characteristics. Network size is not associated with the intensity with which a person uses email, nor is geographic diversity associated with the extent to which a person uses email. For the full sample of respondents, network size is positively associated with the diversity of activities engaged in through email. Those respondents who have engaged in a discussion group through email, discussed research with a colleague in the U.S. or Europe through email, or started a

professional relationship through email, all report broader ranging networks in terms of size. In other words, after controlling for other factors using email is actually having some small effect on the number of people that researchers in these institutions consider to be part of their core professional ties. Indeed, controlling for the lagged dependent variable provides more confidence in this finding. It isn't simply that overtime people make more contacts, while maintaining their previous ties. There is a real effect of email use.

Geographic diversity of ties, on the other hand, is not associated with the extent of email use, but it is associated with the intensity of email use, specifically for women. Within the digital divide literature, email and the Web are cast as essential technologies for, not only researchers, but the developing world as a whole. These technologies are seen as being essential to integration into global knowledge systems. Without access to these resources it is feared by many, particularly within the development community, that less developed countries will fall further and further behind as they will not be able to participate in the global knowledge society. According to these results, then, spending more time using email is associated with maintaining ties in a variety of locations.

It should be kept in mind, however, that this doesn't necessarily indicate that respondents who use email more intensely are maintaining more ties in the core. It simply means that the ties they are maintaining are not simply located in the state or country but in a number of geographic spaces. So in answer to the question posed at the beginning of chapter six, at the present time, it does not appear that email is being used by researchers to integrate themselves more fully into professional networks. Although the relationship between email and network outcomes may not be consistent, the findings that do emerge are instructive. They seem to indicate that for women, email use is more important for predicting career outcomes than it is for men.

The second question addressed the gendered nature of professional ties. Do men's and women's professional ties differ? In relationship to this question, I predicted that 5) women would report smaller professional networks than their male counterparts; 6) they would have less diverse professional networks based on geographic location; 7) they would report a larger proportion of domestic contacts than their male counterparts; and 8) women would report a smaller proportion of foreign contacts than their male counterparts. Finally given the sex make-up of the research organizations in Kerala, Ghana, and Kenya, I also predicted that 9) women would have more diverse professional networks based on gender than their male counterparts; and 10) their professional networks would have a lower proportion of male contacts than their male counterparts.

Again, based solely on the bivariate relationships between gender and these measures, one would conclude that gender is not a primary determinant of network structure. Men's and women's professional networks do not differ in any consistent regard over the two waves of the study. This is not to suggest that gender differences did not emerge only that the gender differences present within wave one, essentially disappeared by wave two to be replaced by *new* gender disparities in network structure. However, two exceptions to this general finding did emerge. First, women's professional ties tended to be composed of fewer foreign ties than their male counterparts (although the finding does disappear by the second wave due to the significant decrease in foreign ties reported by men).

Second, and most significantly, men's and women's professional networks differed in terms of the gender make-up of their contacts. Women report more diverse networks in terms of gender composition because they report more cross-sex ties than their male counterparts. Men report very few women within their close circle of professional relationships. 90% of the

contacts mentioned by men were other men, whereas 63% of women's contacts were men. Because data on the gender composition of professional ties were only gathered in the second wave of the study, comparisons cannot be made over time. However, it is clear simply from this cross-section that male and female researcher's networks do differ in significant respects.

Conducting the multivariate analysis of gender differences revealed that gender is a fairly consistent predictor of network structure. Of the six hypothesis presented in table 8.1, all but one of them are supported. First, I predicted that women would report smaller networks than men. After controlling for the lagged dependent variable, age, family structure, human capital, contextual determinants, technological antecedents and technological behavioral changes, men indeed report larger professional networks in terms of absolute size than their female counterparts. Larger networks are presumed to be less dense, composed of weaker ties, and thus more equipped to achieve successful instrumental outcomes. As such, smaller networks act as one indication that women may indeed be less professionally integrated than men.

A second measure of network range examined in this dissertation is the diversity of professional ties based on their geographic location. Again, my prediction is supported empirically. Men report more diverse ties. In other words, women's ties are more homogenous in terms of location, while men's ties are spread wider in physical space. This provides additional support for the notion that women's networks are denser, ranging less widely than men's contacts. Diversity provides an idea of alters geographic similarity to one another, but they do not indicate where ties are actually located. For that I turn to the measures of proportion. Breaking this measure down into specific locations provide less consistent evidence for gender differences. The only measure to emerge as significantly different for men and women is the proportion of ties within Africa and India but outside of the country or state.

At the two extremes of network location (ties located closest and farthest from ego), my predictions were either not supported or supported only partially. Gender is not a significant predictor of network characteristics domestically (within the country and state, including within the parent organization) or internationally (in the United States and Europe). Women are equally able to integrate themselves into intraogranizational and domestic professional networks (although from the bivariate analysis it appears that there may be a reversal occurring here), whereas men are no better equipped at integrating themselves into core networks (in fact, over the two waves it appears that they are becoming even less integrated internationally). Gender is, however, a significant predictor of the proportion of ties within Africa and India but outside of Ghana, Kenya, and Kerala. Men are more integrated into the national (India) and African scientific systems than women are as they report a larger proportion of ties in Africa and India.

This difference may seem slight, but within these contexts, it may have very real consequences. Within the context of Kerala, for instance, researchers tend to be more integrated into the national community than in Ghana or Kenya. Because India has one of the largest and most developed scientific systems, not only in less developed areas, but in the world, it is not uncommon for researchers from Kerala to be educated, attend workshops, and meetings in other Indian states (Shrum and Campion 2000). In other words, being highly integrated within the national context is likely beneficial due to the developed state of the Indian research and university systems. Being integrated into the broader African scientific system, may again provide researchers with resources lacking within the national system. As such, the fact that women appear to be less integrated at this level, may actually be more significant for their career outcomes then being less integrated internationally.

Turning to remaining two hypotheses provides the strongest support for gender differences in network characteristics. Men's and women's networks do indeed look different from one another based on the gender make-up of ties. Men report a larger proportion of male contacts, whereas women report more gender diversity in their professional ties. In other words, men's networks contain a larger percentage of other men. This is due in part to opportunity and choice. There are simply fewer women than men within the university and research systems of these three locations (with Kerala reporting the largest number of women) for men to develop professional relationships with. In addition, people generally associate with others who are closer in sociodemographic space. This again is due, in part, to opportunity, but also to cultural notions regarding the characteristics of racial and ethnic minority groups, tribal members, caste and class groups, and of course, women. Men's and women's professional interactions may simply feel more strained due to notions of appropriate gender roles and/or aptitudes.

The finding of more gender diversity for women is consistent with Ibarra's (1993) argument regarding the organizational differences in men's and women's contacts in more developed areas. To review his argument, he suggested that because of the gender segregated nature of the workplace (a trend that emerges within the universities and research systems of these three countries as well) minority members of organizations will report more diverse contacts, in part because of opportunity constraints. There are fewer opportunities for women to develop same sex contacts because of they represent numeric minorities within these organizations. In general, diversity is presumed to be positively related to instrumental outcomes as more diverse networks provide access to non-redundant information and other resources. But, as Ibarra suggests, this may not be the case for women within the organizational context, as they will be less likely to form strong ties with powerful individuals i.e. individuals with higher rank

and greater prestige. The question that needs to be examined, then, is to what degree does the gender diversity of women's professional ties equate to more successful instrumental career outcomes? I will address this issue in the next section.

Gender, ICTs, Networks, and Research Outcomes

Finally in chapter seven, I examined the relationship between gender, ICTs, professional networks, and research outcomes in the form of productivity. Three questions were posed. In relationship to the first question, how is access to and use of ICTs related to productivity, I predicted: 1) respondents using email for a wider variety of reasons over time will produce more in foreign venues; 2) respondents using email for a wider variety of reasons over time will produce more in domestic venues; 3) respondents using email more intensely over time will produce more in foreign venues; 4) respondents using email more intensely over time will produce more in domestic venues.

Of my predictions, only two were supported by the empirical findings and then only conditionally for men and the full sample, but not for women. According to the results, the association between changes in ICT behavior and productivity is primarily relegated to research output in foreign journals. Using email more extensively is positively associated with the number of articles published in foreign journals over the five year period proceeding 2005. It is also positively associated with the number of domestic articles published (but only for men). At the same time, however, more intense use of email is negatively associated with research output in the same venue. This suggests that it is not email use just generally that is associated with research outcomes. Instead, it appears that the type of activity one engages in is more important than the amount of time one spends actually using the technology. Furthermore, it also suggests that there is a gendered component to technology use and research outcomes as the association is

only significant for the full sample and men. These findings strongly suggest that the relationship between technological resources and outcomes may lead to greater visibility for men in less developed areas.

The fact that the relationship does not emerge for women, may be more a reflection of the fact that they are not as technologically oriented as men. According to the bivariate analysis done in chapter five between gender and ICT use, women use email less intensely (although not significantly so in the first wave) and for less reasons than men do. While the latter relationship disappears when other factors are controlled for, it may be that if women continue to use email for a variety of reasons over time, the relationship between email use and foreign productivity will emerge for them as well. On the other hand, it may not be a reflection of their technology use, but a reflection of a more local orientation to their careers. Due to a combination of both structural constraints and active choice, women may focus on domestic activities more than international activities.

The next issue examined in chapter seven addressed the question: how is professional network structure related to productivity. I presented six hypotheses in this regard: 1) respondents with larger professional networks will produce more in foreign venues; 2) respondents with larger professional networks will produce more in domestic venues; 3) respondents with more geographically diverse professional networks will produce more in foreign venues; 4) respondents with more geographically diverse professional networks will produce more in domestic venues; 5) respondents with more gender diverse professional networks will produce more in foreign venues; 6) respondents with more gender diverse professional networks will produce more in domestic venues.

Again, the empirical findings do not support the predictions. The only network measure significantly associated with productivity is the gender diversity of the researcher's professional networks. Those researchers with more gender diverse professional ties, also report more publications in domestic journals. In other words, for the full sample, gender diversity is beneficial, as it is generally assumed, for research outcomes in domestic venues. When disaggregated this finding does not hold, but as chapter six demonstrated, women do have more gender diversity within their professional associations. As such this effect may emerge for men as well as women. Indeed, while not significant, the coefficient for women is relatively large, in comparison to the coefficient for men, suggesting that perhaps there is a stronger relationship between these two variables for women as a group.

Finally, chapter seven also examined the question in what ways do men's and women's research output differ? It should be noted at the outset that this sample of researchers are relatively unproductive. As in a more developed context, the highly productive researchers in less developed countries are an elite group, representing a very small minority of all researchers. Both men and women tend to be non-publishers or at the very least not highly productive. The primary question that needs to be examined, in this regard, however, is whether or not women's networks and ICT use are being translated into successful career outcomes. Having said that, I predicted: 1) women will produce less in foreign journals and 2) women will produce more in domestic journals.

No relationship at all emerges between gender and productivity in domestic journals. Indeed, this supports the bivariate analysis between gender and productivity, but it contradicts previous research which suggests women tend to be more productive in local arenas. When other factors are controlled for, women are not more productive in domestic venues. This does,

though, lend some support to the notion that women may simply be more locally oriented to their careers than their male counterparts; not necessarily less productive but productive in different arenas. Turning to the next prediction regarding productivity in foreign venues provides even further support for this notion, as gender is a predictor of foreign journal productivity. Women are less productive in foreign venues.

Implications and Future Directions

Based on the results summarized above, then, how do I answer the three questions noted at the outset of the conclusion? First, gender emerges as one of the stronger predictors of access to and use of technological resources over time, with men being more technologically oriented than women on the majority of the measures examined. However, these differences in access to and use of technologies are not consistently related to either the network structure of men and women's professional ties or to their research career outcomes in terms of productivity levels. What implications do these findings hold, then, for the study of gender differences in less developed scientific communities? Specifically, what implications do they hold for the emphasis placed on technology diffusion by the development community?

There are a number of implications for and directions that future research should take based on the results of this study. Above, I noted that men are more connected over the average three year span between survey waves. However, throughout this paper I've made a point of speaking to the fact that technology diffusion is a process, a trend that needs to be tracked over time. The strength of this research is that it begins to address the need for over time studies on technology diffusion. However, the process is not over. Technology will continue to diffuse in unique ways in these areas. Given a longer interval between survey periods, it is in fact

probable that there will be a flattening of the technology curve, particularly for males, at which point many of the gender differences currently observed will disappear.

Indeed, a number of studies note that the diffusion curve (whether adoption diffusion or use diffusion) is S-shaped and can be divided into three stages: "introduction stage in which the initial rate of growth is slow until it reaches critical mass; growth stage when the rate of growth is steep and upward, and the maturity stage where" the curve flattens (Shih and Venkatesh 2004: 61). In other words, given a longer interval of time, it may be that male researchers will enter the third stage of adoption and use diffusion, while women enter the second (if they have not already entered the second stage) of adoption and use diffusion resulting in their 'catching up' with male researchers. If this relationship between time and diffusion translates beyond more developed contexts, the question will then be, whether or not being an earlier adopter and user of these technologies translates into any sort of differential career outcomes?

In order to answer the previous question, future studies must continue to track trends associated with technology diffusion. However, at this point, it is safe to say that being earlier adopters of technologies, in this context, does not appear to be translating into improved outcomes for males over females. Being male was positively related to many of the ICT measures analyzed, but it is not generally related to research outcomes. After controlling for other factors, gender differences in productivity are essentially nil. As such, it may be that placing the emphasis on access to technological resources is correctly placed. Women are able to turn what amounts to less access and less intense and extensive use of resources and produce at the same rate as their male counterparts, except in foreign venues. As such, if women desire to be more visible outside of the local scientific community it may be that better access to and more use of these resources be encouraged.

However, this statement should be interpreted with caution, particularly in light of the literature regarding the socially constructed nature of technologies and science. The Internet, email, and other communication technologies are embedded within the social context in which they are used. Their distribution and use will thus reflect both global differences in power and resources as well as the gendered relations preexisting within these environments. Gender roles, expectations for appropriate behavior, and cultural restrictions placed on interactions with other males (to the extent that they exist), will not simply disappear once women have a technology which enables them to interact with others without the criterion of co-presence. Instead, women and men are equally committed to the standards and norms of behavior within their society. As such, women will likely use these technologies in ways that are consistent with their pre-existing personal and professional goals, as well as cultural norms of appropriate and inappropriate behavior.

Furthermore, simply sitting down at a keyboard does not eliminate gender stereotypes or prejudices on the part of other, male researchers. Based on Ridgeway's (2004) elucidation of the gender system discussed in chapter two, when men and women are interacting with one another, they employ well established cultural schemas regarding appropriate male and female behavior. They employ these schemas largely on an unconscious level, but they influence not only the way people treat one another in an interactional context but they also influence the way that individual's behave and expect to be treated in turn.

In addition, future research in this area should continue to track the spread of personal computers, the Web, and email within the home. Home use may emerge as a significant factor in female researcher's use of technology. If cultural and social barriers exist within the workplace, the home may be the environment in which women's use of technology could be expanded with

few constraints. Not only should future studies track new changes, but the data also exist to examine the pre-Internet lives of researchers and compare them to their research careers fifteen years later. As I noted in chapter three, the data reported here are just one part of a three wave survey. Returning to the first wave of researchers interviewed in 1994 would provide the first empirical study of pre and post Internet science in less developed areas. Such a study would provide a glimpse into the differences in network structure and productivity levels pre and post communication technologies, essentially establishing more direct evidence for a causal relationship between ICTs and career outcomes.

Finally, in what way are researchers actually *using* new technologies? Are they using them to integrate themselves more fully in professional networks with other researchers? Are they using them to be more productive? In general, the answer is 'no'. Researchers in Ghana, Kenya, and Kerala are certainly not using the Internet and email in predictable ways. Instead, much of the evidence seems to suggest that female scientists, in particular, are using new ICTs in a manner that is consistent with their existing social and professional realities. In the three to five years since the first wave of this study, not a lot has changed. Women's productivity levels and social ties have remained relatively stable, and the differences that do emerge are unexpected and perhaps worrisome. In fact, the most contradictory finding to emerge is in regards to changes in women's professional network structure. Women's networks appear to be contracting over time; becoming smaller. As a group, they are not as integrated as they were in an earlier period. Men's productivity levels and networks, on the other hand, seem to be expanding, except in that area where it is hypothesized that the Internet will make the most difference; foreign ties are not increasing, and in fact are decreasing. Why, as the technology

thought to connect people with others spreads, are women reporting fewer close professional ties?

Before addressing that question, I should first address the issue of foreign versus local ties. The finding that foreign ties are not increasing (for either men or women) in conjunction with the greater degree of access to new technologies may not be all that surprising. Such ties are difficult to maintain, even between colleagues in more research rich environments. In the context of scientific systems lacking in resources, possessing slow and unreliable Internet connections, and old or malfunctioning equipment, such ties become even more difficult to maintain. The difficulty associated with maintaining such ties, furthermore, likely increases rather than decreases over time. When initial contact has been made, tie maintenance may seem effortless, but with time and distance, there appears to be a decaying effect, regardless of ease associated with technology use. This, of course, refers specifically to foreign ties.

Women's networks are contracting generally, not specifically related to those relationships located outside of the immediate environment. One possible reason for this finding may be due to an issue mentioned briefly in chapter six. Professional network ties are only one network in which men and women are embedded. They are also embedded in ties of friendship and kin, to name a few. These ties require time, energy, and investments as much as (if not more) than professional ties. Particularly within the context of less developed countries, where gender roles may still posit that women take primary responsibility for domestic activities, it may be that even with the expansion of communication technologies, women are unable to work at their professional ties because of time constraints associated with their kin-ties. Future studies would benefit greatly our understanding of the gendered nature of science in less developed areas

if they were to incorporate other measures of network structure within which men and women are embedded.

Additionally, the fact that women's professional ties are contracting may reflect the way in which gendered schemas influence relationship formation. Even in situations in which men and women do not have to interact face-to-face, the cultural norms influencing gendered expectations may limit women's and men's abilities or even desires to form cross-sex professional ties. In light of the argument that, without international visibility, researchers in less developed areas are not contributing to the global scientific community, these findings may indeed be cause for some concern. To be sure, much of the argument for a focus on women in development more generally and women researchers more specifically, is that these groups represent untapped resources. Until such resources are fully utilized, economic, cultural, and scientific life will not be able to meet its full productive potential. This argument, however, in many respects reifies the core/periphery assumptions regarding researchers in more and less developed areas. Perhaps international visibility is important only to the extent that acknowledgment of research activity by those researchers in wealthier countries provides for scientific recognition, but to be involved in research shouldn't be contingent upon foreign approval. At the same time, it is important to emphasize men and women are not completely isolated. Researchers in less developed areas are connected with other researchers at the local and intermediate levels.

Just as researchers are not entirely isolated they are also not entirely unproductive. In fact, their research careers in some ways closely model those in more developed systems. The most productive researchers are an elite group. Most researchers, either due to structural constraints or a conscious opting out of the publication process, don't publish at all. This is no

different than what occurs in the United States. It may be a reflection of structural constraints that women are less productive, but it also may be a reflection of the fact that they simply place different emphasis on what matters for their careers. Perhaps the 'publish or perish' lifestyle marking careers within highly functioning research institutions is generally less appealing for female researchers, and they actively choose an alternate career path. The same may be true regarding the more local orientation noted by women compared to men. Such an orientation to the research career may reflect an active move away from the foreign towards the local and not simply structural constraints making it difficult for women to publish and make contacts in foreign venues. Perhaps instead of examining the gender differences in productivity and networking, the question should be why women opt out of certain publication and networking patterns at a greater rate than men.

The focus in this study has been on the relationship between changes in access to the Internet, email, and personal computers and career and social outcomes. Due to data constraints, however, I did not examine changes in the career related to changes in access to and use of mobile phones. Data on mobile phones was gathered in the second wave of the survey but not the first. Mobile phone technology has been conceived of as a bridging technology for less developed areas (UNCTD 2007). Easy to use with little to no training and relatively affordable, many see significant potential within the technology for closing the digital divide gap. As such, future research must continue to track the diffusion and consequences of this very important tool on social, political, and economic life.

Another dimension not explored in this dissertation, but one that is necessary in order to fully understand the issues addressed in this dissertation, is a look at female researchers secondary and post secondary educational experiences. Part of the difficulty of studying gender

differences in science is that there are so few women in the scientific career of less developed areas to begin with. Tracking the research career after the decision to enter into such an occupation has been reached, makes it impossible to determine why it is that women and girls opt out of entering into such occupations to begin with.

It is fairly certain, however, that with so few women entering into a scientific career in these areas, newer generations of female researchers lack role models, mentors, and sources of informal social support that are so important throughout the career trajectory but particularly early on in the educational experience. Another direction future research in this area should take is to examine not just network ties, but *resources*. Social and professional networks are important because of the resources embedded within ties. It would be interesting to determine what types of resources are being exchanged within professional networks and to then examine the relationship between types of resources and particular outcomes.

Finally, among the limited number of studies done on female researchers in less developed areas, one of the more consistent findings was in regards to the localism argument. In this dissertation, I included travel experience outside of the country of origin as a measure of localism. This emerged as one of the least useful measures predicting career outcomes in access to technology, network structure, and research output. With a few exceptions, it can generally be concluded that localism is unrelated to the career outcomes of men and women in less developed areas. More time abroad is significantly related to the number of publications in foreign and domestic journals and the number of published reports. But this appears to be a zero-sum game in which travel leads to more publications in foreign venues but fewer in domestic venues and a fewer number of reports. Theoretically speaking, publications in foreign venues make a researcher more visible to the scientific community outside of the local area, but at what cost?

Does an increase in cosmopolitanism lead to a drain on the national scientific community? Does increased travel simply serve to reify the central position of the scientific core? Although there is not enough information here to suggest a firm response to this, it is clear that perhaps the understanding of localism needs to be reformulated.

In the past, development experts, policy makers, government officials, and academics alike placed a great deal of confidence in the ability of technology to alter social realities all around the world. Technological determinism, and all the optimism associated with it, framed much of the thinking of those concerned with the topic of economic and social development. From large-scale agricultural equipment, to the building of roads and dams, technology was the key to success. The Internet is no different. Although it is framed in a context of participation and equality, these same experts have turned to the technology with all the hope they placed in the technologies of the past, either to create economic and social progress or merely to connect people with one another in new and significant ways. The results of my research demonstrate that, while these aspirations may not be entirely played out, there is certainly much room for doubt, and continued need for explanation, about the nature of the relationship between new technologies and social change.

Regardless of how it is conceived, whether it is being deplored or celebrated, globalization is indeed altering social experiences and realities around the world. As such, what the Internet, email, and even mobile phones are today, the way they are used, the consequences they have for social life, will not be the same 50 years from now or even five years from now. New ICTs, new technologies generally, are not merely created, placed in the world, and then simply blended into people's lives in predictable ways. Social life is a fluid process and the role of technology in that process is also fluid. The way technologies impact the research career and

they way women *choose* to use the technologies in their career, are outcomes that are likely to be slow in the making.

REFERENCES

Abbate, Janet. 2000. *Inventing the Internet*. Cambridge, MA: MIT Press.

Acosta-Belen, Edna and Christine E. Bose. 1990. "From Structural Subordination to Empowerment: Women and Development in Third World Contexts." *Gender and Society* 4: 299-320.

Allison, Paul D. 2005. *Fixed Effects Regression Models for Longitudinal Data Using SAS*. Cary, NC: SAS Institute Inc.

Allison, Paul D. and J. Scott Long. 1990. "Departmental Effects on Scientific Productivity." *American Sociological Review* 55: 469-478.

Allison, Paul D., J. Scott Long, and Tad K. Krauze. 1982. "Cumulative Advantage and Inequality in Science." *American Sociological Review* 47: 615-25.

Amancio, L. 2003. "Gender and Science in Portugal." *Portugese Journal of Social Science* 1(3): 185-198.

Anderson, Meredith and Wesley Shrum. 2007. "Circumvention and Social Change: ICTs and the Discourse of Empowerment." *Women's Studies in Communication* 30: 229-253.

Anderson, Warwick. 2002. "Postcolonial Technoscience." *Social Studies of Science* 32:643-658.

Astin, Helen & Diane Davis. 1985. "Research Productivity Across the Life- and Career Cycles: Facilitators and Predictors for Women." Pp. 147-160 *Scholarly Writing and Publishing: Issues, Problems, and Solutions*, edited by M.F. Fox. Boulder, CO: Westview.

Astin, Helen & Jeffrey Milem. 1997. "The Status of Academic Couples in U.S. Institutions." Pp. 128-155 in *Academic Couples: Problems and Promises*, edited by M.A. Ferber & J.W. Loeb. Urbana, IL: University of Illinois Press.

Attewell, Paul. 2001. "The First and Second Digital Divides." *Sociology of Education* 74:252-259.

Barber, Leslie A. 1995. "U.S. Women in Science and Engineering, 1960-1990: Progress Toward Equity?" *The Journal of Higher Education* 66(2): 213-234.

Bastani, Susan. 2007. "Family Comes First: Men's and Women's Personal Networks in Tehran." *Social Networks* 29: 357-374.

Beaver, D. and R. Rosen. 1978. "Studies in Scientific Collaboration: Part I – The Professional Origins of Scientific Co-authorship." *Scientometrics.* 1:64-84.

Bell, Daniel. 1994. "The Coming of Post-Industrial Society." In *Class, Race, and Gender: Social*

Stratification in Sociological Perspective, edited by D. B. Grusky. Oxford: Westview Press.

—. 1995. "Sociohistorical Technology Studies." Pp. 229-256 in *Handbook of Science and Technology Studies,* edited by S. Jasanoff, G.E. Markle, J.C. Petersen and T. Pinch. Thousand Oaks, CA: Sage Publications.

Bimber, B. 2000. "Measuring the Gender Gap on the Internet." *Social Science Quarterly* 81(3): 868-876.

Blau, Judith R. 1974. "Patterns of Communication Among Theoretical High Energy Physicists." *Sociometry* 37(3): 391-406.

Boden, Deirdre and Harvey L. Molotch. 1994. "The Compulsion of Proximity." Pp. 257-286 in *NowHere: Space, Time and Modernity,* edited by D. Boden and H. L. Molotch. Berkeley: University of California Press.

Boneva, B. and R. Kraut. 2002. "Email, Gender, and Personal Relationships." Pp. 372-402 in *The Internet in Everyday Life,* edited by B. Wellman and C. Haythornwaite. Malden, MA: Blackwell Publishing.

Boneva, B., Kraut, R., and D. Frohlich. 2001. "Using Email for Personal Relationships: The Difference Gender Makes." *American Behavioral Scientist* 45: 530-549.

Bowden, Gary. 1995. "Coming of Age in STS: Some Methodological Musings." Pp. 64-79 in *Handbook of Science and Technology Studies,* edited by S. Jasanoff, G.E. Markle, J.C. Petersen and T. Pinch. Thousand Oaks, CA: Sage Publications.

Bradshaw, York. 1987. "Urbanization and Development: A Global Study of Modernization, Urban Bias, and Economic Dependency." *American Sociological Review* 52: 224-239.

Bradshaw, York. 1988. "Reassessing Economic Dependency and Uneven Development: the Kenyan Experience." *American Sociological Review* 53(5): 693-708.

Bradshaw, Y., Y.K. Kim, and B. London. 1993. "Transnational Economic Linkages, the State, and Dependent Development in South Korea, 1966-1988: A Time Series Analysis." *Social Forces* 72(2): 315-345.

Brown, Susan A. 2008. "Household Technology Adoption, Use, and Impacts: Past, Present, and Future." *Information Systems Frontiers* 10: 397-402.

Bucchi, Massimiano. 2002. *Science in Society: An Introduction to Social Studies of Science*. New York: Routledge.

Burrelli, Joan. 2008. "Thirty-Three Years of Women in S&E Faculty Positions." National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences.

Bush., Corlann Gee. 1983. “Women and the Assessment of Technology: To Think, to be, to Unthink, to Free.” In *Machina Ex Dea: Feminist Perspectives on Technology*, edited by J. Rothschild. Elmsford, NY: Pergamon.

Callon, M. 1995. “Four Models for the Dynamics of Science.” Pp. 29-63 in *Handbook of Science and Technology Studies*, edited by S. Jasanoff, G.E. Markle, J.C. Petersen and T. Pinch. Thousand Oaks, CA: Sage Publications.

Campbell, Karen E. 1988. “Gender Differences in Job-Related Networks.” *Work and Occupations* 15(2): 179-200.

Campion, Patricia and Wesley Shrum. 2004. "Gender and Science in Development: Women Scientists in Africa and India." *Science Technology and Human Values* 29(4): 459-485.

Cardoso, Fernando Henrique and Enzo Faletto. 1979. *Dependency and Development in Latin America*. Berkley and LA, CA, USA, University of California Press.

Carley, Kathleen and Kira Wendt. 1991. “Electronic Mail and Scientific Communication.” *Knowledge: Creation, Diffusion, Utilization* 4: 406–440.

Castells, Manuel. 2000. *The Information Age: Economy, Society, and Culture: The Rise of the Network Society*. Malden, Massachusetts: Blackwell Publishers.

Chakravarthy, R. 1986. “Productivity of Indian Women Scientists.” *Productivity* 3: 259-269.

Chafetz Saltzman, Janet. 1997. “Feminist Theory and Sociology: Underutilized Contributions for Mainstream Theory.” *Annual Review of Sociology* 23: 97-120.

—. 2001. “Theoretical Understandings of Gender: A Third of a Century of Feminist Thought in Sociology.” In *Handbook of Sociological Theory*, edited by J. Turner. Klewer/Plenum Publishers.

Chase-Dunn, Christopher. 1975. “The Effects of International Economic Dependence on Development and Inequality: A Cross-National Study.” *American Sociological Review* 40(6): 720-738.

Chirot, Daniel and Thomas D. Hall. 1982. “World-System Theory.” *Annual Review of Sociology* 8: 81-106.

Clarke, Adele E. and Susan Leigh Star. 2003. “Science, Technology, and Medicine Studies.” Pp. 539-574 in *Handbook of Symbolic Interactionism*, edited by L. T. Reynolds and N. J. Herman Kinney. Walnut Creek, CA: Alta Mira Press.

Clewell, Beatriz Chu and Patricia B. Campbell. 2002. “Taking Stock: Where We’ve Been,

Where We Are, Where We're Going." *Journal of Women and Minorities in Science and Engineering* 8: 255-284.

Cohen, Joel. 1996. "Computer Mediated Communication and Publication Productivity Among Faculty." *Internet Research* 2/3: 41–63.

Cole, Jonathan. 1979. *Fair Science: Women in the Scientific Community*. New York: Free Press.

Cole, Stephen and Jonathan R. Cole. 1967. "Scientific Output and Recognition: A Study in the Operation of the Reward System in Science." *American Sociological Review* 32(3): 391-403.

Cole, Jonathan and Harriet Zuckerman. 1984. "The Productivity Puzzle: Persistence and Change in Patterns of Publication of Men and Women Scientists." *Advances in Motivation and Achievement* 2: 217-258.

—. 1987. "Marriage, Motherhood, and Research Performance in Science." *Scientific American* 256: 119-125.

Collins, Harry M. 1981. "Knowledge and Controversy: Studies in Modern Natural Science." Special Issue of *Social Studies of Science* 11(1).

—. 1983. "The Sociology of Scientific Knowledge: Studies of Contemporary Science." *Annual Review of Sociology* 2: 265-285.

—. 1989. "Computers and the Sociology of Scientific Knowledge." *Social Studies of Science* 19(4): 613-624.

Collins, Harry M. and Trevor Pinch. 1993. *The Golem: What Everyone Should Know About Science*. Cambridge, UK, Cambridge University Press.

—. 1998. *The Golem at Large-What You Should Know About Technology*. Cambridge, UK: Cambridge University Press.

Connell, R.W., and Julian Wood. 2002. "Globalization and Scientific Labour: Patterns in a Life-History Study of Intellectual Workers in the Periphery." *Journal of Sociology* 38(2): 167-90.

Cooper, J. 2003. *Gender and Computers: Understanding the Digital Divide*. Mahwah, N.J: Lawrence Erlbaum.

Crane, Diane. 1972. *Invisible College: Diffusion of Knowledge in Scientific Communities*. Chicago, IL, USA, University of Chicago Press.

Creamer, Elizabeth. 1999. "Knowledge Production, Publication Productivity, and Intimate Academic Partnerships." *Journal of Higher Education* 70 (May/June): 216-77.

Crenshaw, Edward. 1991. “Foreign Investment as a Dependent Variable: Determinants of Foreign Investment and Capital Penetration in Developing Nations.” *Social Forces* 69(4): 1169-1182.

Cuenca, Angela Maria Belloni and Ana Cristina d’Andretta Tanaka. 2005. “The Internet Influence on the Academic Scientific Public Health Community.” *Rev Saude Publica* 39(5).

Davis, F. D. 1989. “Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology,” *MIS Quarterly* 13(3): 319-339.

Davidson, Theresa, R. Sooryamoorthy and Wesley Shrum. 2002. “Kerala Connections: Will the Internet Affect Science in Developing Areas?” In *The Internet in Everyday Life*, edited by B. Wellman and C. Haythornthwaite. Malden, MA, USA, Blackwell.

De Roy, Olivier Coeur. 1997. “The African Challenge: Internet, Networking and Connectivity Activities in a Developing Environment.” *Third World Quarterly* 18: 883-899.

DiMaggio, Paul E. and Walter W. Powell. 1983. “The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields.” *American Sociological Review* 48(2): 147-160.

DiMaggio, Paul E., Eszter Hargittai, W. Russell Neuman, and John Robinson. 2001. “Social Implications of the Internet.” *Annual Reviews of Sociology*: 307-336.

Drori, Gili S., John W. Meyer, Francisco O. Ramirez, and Evan Schofer. 2003. *Science in the Modern World Polity: Institutionalization and Globalization*. Stanford, CA: Stanford University Press.

Duque, Ricardo B., Marcus A. Ynalvez, R. Soorymoorthy, Paul Mbatia, Dan B. Dzrogbo and Wesley Shrum. 2005. "Collaboration Paradox: Scientific Productivity, the Internet, and Problems of Research in Developing Areas." *Social Studies of Science* 35(5): 755-785.

Economy Bureau. 2008. “Kerala Betters Growth Rate: Economic Review.” *The Financial Express*, March 6, 2008. Retrieved June 6, 2009 (http://www.financialexpress.com/news/kerala-betters-growth-rate-economic-review/280973/).

Ekdahl, Peter and Lena Trojer. 2002. "Digital Divide; Catch up for What?" *Gender, Technology, and Development* 6(1): 1-20.

Emirbayer, Mustafa and Anne Mische. 1999. “What is Agency?” *American Journal of Sociology* 106: 187-211.

Escobar, Arturo. 1995. *Encountering Development: The Making and Unmaking of the Third*

World. Princeton, N.J.: Princeton University Press.

Escobar, Arturo. 2001. "Culture Sits in Places: Reflections on Globalism and Subaltern Strategies of Localization." *Political Geography* 20(2): 139-174.

Finkel, S. E. 1995. *Causal Analysis With Panel Data*. Thousand Oaks, CA: Sage Publications.

Firebaugh, Glenn. 1992. "Growth Effects of Foreign and Domestic Investment." *American Journal of Sociology* 98(1): 105-130.

Firebaugh, Glenn and Frank D. Beck. 1994. "Does Economic Growth Benefit the Masses? Growth, Dependence, and Welfare in the Third World." *American Sociological Review* 59(5): 631-653.

Fischer, Claude. 1982. *To Dwell Among Friends*. Chicago: University of Chicago

Fischer, Claude, and Stacey Oliker. 1983. "A Re- search Note on Friendship, Gender, and the Life Cycle." *Social Forces* 62:124-132.

Ford, N. and D. Miller. 1996. "Gender Differences in Internet Perceptions and Use." *Aslib Proceedings* 48:183-192.

Fox, Mary Frank. 1991. "Gender, Environmental Milieu, and Productivity in Science." Pp. 188 204 in *The Outer Circle: Women in the Scientific Community*, edited by H. Zuckerman, JR Cole, and JT Bruer. New York, NY: Norton.

—. 1995. "Women and Scientific Careers." Pp. 205-223 in *The Handbook of Science and Technology Studies,* edited by G. M. Sheila Jasanoff, James Peterson, and Trevor Pitch. Newbury Park: Sage.

—. 1996. "Women, Academia, and Careers in Science." Pp. 265-269 in C.S. Davis, A.B. Ginorio, C. S. Hollenshead, B.B. Lazarus, P.M. Rayman, & Associates (eds.), *The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering*. San Francisco: Jossey-Bass.

—. 1999. "Gender, Hierarchy, and Science." In *Handbook of Sociology of Gender*, edited by J. S. Chafetz. New York, NY: Kluwer Academic/Plenum Publishers.

Frame, J. Davidson. 1980. "Measuring Scientific Activity in Lesser Developed Countries." *Scientometrics* 2: 133-45.

Frame J. Davidson and Mark P. Carpenter. 1979. "International research collaboration." *Social Studies of Science* 9: 481-497.

Frame, J. Davidson, Francis Narin, and Mark P. Carpenter. 1977. "The Distribution of World

Science." *Social Studies of Science* 7: 501-16.

Frank, Andre G. 1979. *Dependent Accumulation and Underdevelopment*. New York, NY: Monthly Review Press.

Franke, Richard W. and Barbara H. Chasin. 1994. *Kerala: Radical Reform as Development in an Indian State*. Oakland, CA: Food First.

Freeman, Linton C. 1984. "The Impact of Computer Based Communication on the Social Structure of an Emerging Scientific Specialty." *Social Networks* 6: 201–221.

Friedmann, Harriet. 1988. "Form and substance in the analysis of the world economy." Pp. 304 326 in *Social Structures: A Network Approach*, edited by B. Wellman and S.D. Berkowitz. Cambridge: Cambridge University Press.

Gaillard, Jacques. 1991. *Scientists in the Third World*. Lexington: University of Kentucky Press.

Gaillard, Jacques, V.V. Krishna, and Roland Waast. 1997. "Introduction: Scientific Communities in the Developing World." In *Scientific Communities in the Developing World*, edited by J. Gaillard, VV Krishna, and R. Waast. London: Sage Publications.

Gender and Development Group and The Global Information and Communication Technologies Department. 2004. *Engendering Information and Communication Technologies: Challenges and Opportunities for Gender-Equitable Development*. Washington, DC: The World Bank.

Gieryn, Thomas. 2006. "City as Truth-Spot: Laboratories and Field-Sites in Urban Studies." *Social Studies of Science* 36: 5-38.

Gjerde, Per F. and Kim Cardilla. 2005. "Social Network Research in the Era of Globalization: Moving Beyond the Local." *Human Development* 48: 95-101.

Granovetter, Mark. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78: 1360-80.

Gupta, Namrata and A. K. Sharma. 2002. "Women Academic Scientists in India." *Social Studies of Science*. 32: 901–915.

Gupta, Namrata and A.K. Sharma. 2003. "Patrifocal Concerns in the Lives of Women in Academic Science: Continuity of Tradition and Emerging Challenges." *Indian Journal of Gender Studies* 10(2): 279-305.

Harrison, David. 1988. *The Sociology of Modernization and Development*. London: Unwin Hyman.

Hart, Keith. 2000. *The Memory Bank: Money in an Unequal World*. London: Profile Books.

Held, David, Anthony McGrew, David Goldblatt, and Jonathan Perraton. 1999. *Global Transformations: Politics, Economics, and Culture.* Cambridge: Polity Press.

Henke, Christopher R. and Thomas F. Gieryn. 2007. "Sites of Scientific Practice: The Enduring Importance of Place." Pp. 353-76 in *The Handbook of Science and Technology Studies*, edited by E. J. Hackett. Cambridge, MA: MIT Press.

Hicks, D.M., and J.S. Katz. 1996. "Where is science going?" *Science, Technology & Human Values* 21: 379-406.

Hirst, Paul. 1997. "The Global Economy: Myths and Realities." *International Affairs* 73: 409-425.

Howard, P., Rainie, L., and S. Jones. 2002. "Days and Nights on the Internet." Pp. 45-73 in *The Internet in Everyday Life*, edited by Barry Wellman and Caroline Haythornthwaite. Malden, MA: Blackwell Publishing.

Huntington, Samuel P. 1993. "The Clash of Civilizations." *Foreign Affairs* 72(3): 22-50.

Hurlbert, Jeanne S. and Alan C. Acock. 1990. "The Effects of Marital Status on the Form and Composition of Social Networks." *Social Science Quarterly* 71:163-74.

Hurlbert, Jeanne S., Valerie A. Haines, and John J. Beggs. 2000. "Core Networks and Tie Activation: What Kinds of Routine Networks Allocate Resources in Nonroutine Situations." *American Sociological Review* 65(4): 598-618.

Huyer, Sophia and Marilyn Carr. 2002. "Information and Communication Technologies: A Priority for Women." *Gender, Technology, and Development* 6(1): 85-100.

Ibarra, Herminia. 1993. "Personal Networks of Women and Minorities in Management: A Conceptual Framework." *Academy of Management Review* 18(1): 56-87.

Inkeles, Alex and David H. Smith. 1974. *Becoming Modern: Individual Change in Six Developing Countries*. Cambridge, MA: Harvard University Press.

Isbister, J. 2003. *Promises Not Kept: Poverty and the Betrayal of Third World Development.* Kumarian Press.

James, Jeffrey. 2007. "From Origins to Implications: Key Aspects in the Debate Over the Digital Divide." *Journal of Information Technology* 22: 284-295.

Johnson, D. R. 1995. "Alternative Methods for the Quantitative Analysis of Panel Data in Family Research: Pooled Time-Series Models." *Journal of Marriage and the Family* 57(4): 1065-1077.

Katz, James E. 1994. "Geographical Proximity and Scientific Collaboration." *Scientometrics* 31: 31-43.

Katz, James E., Rice, Ronald E., and P. Aspden. 2001. "The Internet, 1995-2000." *The American Behavioral Scientist* 45: 405-419.

Katz, James E. and Ronald E. Rice. 2002. *Social Consequences of Internet Use: Access, Involvement, and Interaction*. Cambridge, MA: The MIT Press.

Keller, Evelyn Fox. 1995. "The Origin, History and Politics of the Subject Called 'Gender and Science." In *The Handbook of Science and Technology Studies*, edited by S. Jasanoff, G.E. Markle, J.C. Peterson, and T. Pinch. Thousand Oaks, CA: Sage.

Kemelgor, Carol and Henry Etzkowitz. 2001. "Overcoming Isolation: Women's Dilemmas in American Academic Science." *Minerva* 39: 239-257.

Kirkup, Gill and Laurie Smith Keller. 1992. *Inventing Women: Science, Technology, and Gender*. Cambridge, MA: The Open University.

Knorr-Cetina, Karin. 1995. "Laboratory Studies: The Cultural Approach to the Study of Science." Pp. 229-256 in *Handbook of Science and Technology Studies*, edited by S. Jasanoff, G.E. Markle, J.C. Petersen and T. Pinch. Thousand Oaks, CA: Sage Publications.

Kole, E. 1998. "Myths and Realities in Internet Discourse." Pp. 343-360 in *Gazette*. London, Thousand Oaks, & New Delhi: Sage Publications.

Kumar, KG. 2007. "Jobless No More?" *The Hindu*, October 8, 2007. Retrieved June 6, 2009 (http://www.thehindubusinessline.com/2007/10/08/stories/2007100850911500.htm).

Kumar, N. 2001. "Gender and Stratification in Science: an Empirical Study in the Indian Setting." *Indian Journal of Gender Studies* 8: 51-67.

Kyvik, S and I. Larsen. 1994. "International Contact and Research Performance." *Scientometrics* 29: 161-172.

Kyvik, S. and M. Teigen. 1996. "Child Care, Research Collaboration, and Gender Differences in Scientific Productivity." *Science, Technology, and Human Values* 21: 54-71.

Latour, Bruno. 1984. *Science in Action*. Cambridge, MA: Open University Press and Harvard University Press.

—. 2005. *Reassembling the Social*: *An Introduction to Actor-Network Theory*. Oxford: Oxford University Press.

Latour, Bruno and Steve Woolgar. 1979. *Laboratory Life: The Social Construction of Scientific*

Facts. Beverly Hills, CA: Sage Publications.

Leahey, E. 2006. "Gender Differences in Productivity: Research Specialization as a Missing Link." *Gender and Society* 20(6): 754-780.

Leonard, E. 2003. *Women, Technology, and the Myth of Progress.* Upper Saddle River, New Jersey: Prentice Hall.

Levy, Marion J. 1972. *Modernization: Latecomers and Survivors*. New York: Basic Books.

Licoppe, Christian and Zbigniew Smoreda. 2005. "Are Social Networks Technologically Embedded? How Networks are Changing Today with Changes in Communication Technology." *Social Networks* 27(4): 317-335.

Lin, Nan. 2001. *Social Capital*. Cambridge University Press.

Long, J. Scott. 1990. "The Origins of Sex Differences in Science." *Social Forces* 68: 1297-1316.

—. 1992. "Measures of Sex Differences in Scientific Productivity." *Social Forces* 71: 159-178.

Long, J. Scott and Mary Frank Fox. 1995. "Scientific Careers: Universalism and Particularism." *Annual Review of Sociology* 21: 45-71.

Luukkonen, T., Persson, O., and G. Sivertsen. 1992. "Understanding Patterns of International Scientific Collaboration." *Science, Technology, and Human Values* 17: 101-126.

Lyson, Thomas A., Robert J. Torres, and Rick Welsh. 2001. "Scale of Agricultural Production, Civic Engagement, and Community Welfare." *Social Forces* 80(1): 311-327.

Mahlck, Paula. 2001. "Mapping Gender Differences in Scientific Careers in Social and Bibliometric Space." *Science, Technology, and Human Values* 26(2): 167-190.

Mahroum, S. 2000. "Scientists and Global Spaces." *Technology in Society* 22: 513-523.

Marsden, Peter, V. 1987. "Core Discussion Networks of Americans." *American Sociological Review* 52(1): 122-131.

—. 1990. "Network Data and Measurement." *Annual Review of Sociology* 16: 435-63.

Marsden, Peter V. and Karen E. Campbell. 1984. "Measuring Tie Strength." *Social Forces* 63(2): 482-501.

Marsden, Peter V. and Jeanne S. Hurlbert. 1988. "Social Resources and Mobility Outcomes: A Replication and Extension." *Social Forces* 66(4): 1038-1059.

Mason, Mary Ann and Marc Goulden. 2004. "Marriage and Baby Blues: Redefining Gender Equity in the Academy." *Annals of the American Academy of Political and Social Science* 596: 86-103.

McElhinney, Stephen. 2005. "Exposing the Interests: Decoding the Promise of the Global Knowledge Society." *New Media and Society* 7(6): 748-769.

McGinnis, Robert, Paul D. Allison, and J. Scott Long. 1982. "Postdoctoral Training in Bioscience: Allocation and Outcomes." *Social Forces* 60(3): 701-722.

McMichael, Philip. 1996. "Globalization: Myths and Realities." *Rural Sociology* 61(1): 25-55.

McMichael, Philip. 2000. *Development and Social Change: A Global Perspective.* Pine Forge Press.

McPherson, Miller, Lynn Smith-Lovin, and James M. Cook. 2001. "Birds of a Feather: Homophily in Social Networks." *Annual Review of Sociology* 27: 415-44.

Merton, Robert K. 1973. *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago: The University of Chicago Press.

Meyer, John W., John Boli, George M. Thomas, and Francisco O. Ramirez. 1997. "World Society and the Nation-State." *American Journal of Sociology* 103(1): 144-81.

Miller, B. Paige, R. Sooryamoorthy, Meredith Anderson, Antony Palackal, and Wesley Shrum. 2006. "Gender and Science in Developing Areas: Has the Internet Reduced Inequality." *Social Science Quarterly* 87(3): 679-689.

Ministry of Health and Family Welfare. 2006. "2005-2006 National Family Health Survey: Fact Sheet Kerala." Government of India, Retrieved June 6, 2009 http://www.nfhsindia.org/pdf/KE.pdf.

Mitter, Swasti. 2004. "Globalization, ICTs, and Economic Empowerment: A Feminist Critique." *Gender, Technology, and Development* 8: 5-29.

Mitter, Swasti and Sheila Rowbotham. 1995. *Women Encounter Technology: Changing Patterns of Employment in the Third World*. London: Routledge.

Miyata, K. 2002. "Social Supports for Japanese Mothers Online and Offline" Pp. 520-48 in *The Internet in Everyday Life*, edited by B. Wellman and C. Haythornthwaite. Oxford: Blackwell.

Mok, Diana, Juan-Antonio Carrasco and Barry Wellman. 2009. "Does Distance Still Matter in the Age of the Internet?" *Urban Studies* Forthcoming.

Mohindra, KS. 2003. "A report on women Self-Help Groups (SHGs) in Kerala state, India: a

public health perspective". *Université de Montréal Département de médecine sociale et prévention*.)

Monhardt, R., Tillotson, J., and P. Veronesi. 1999. "Same Destination, Different Journeys: A Comparison of Male and Female Views on Becoming and Being a Scientist." *International Journal of Science Education* 21: 533-551.

Moore, Gwen. 1990. "Structural Determinants of Men's and Women's Personal Networks." *American Sociological Review* 55(5): 726-735.

Morgall, Janine M. 1993. *Technology Assessment: A Feminist Perspective*. Temple University Press.

Najman, Jake M. and Belinda Hewitt. 2003. "The Validity of Publication and Citation Counts for Sociology and Other Selected Disciplines." *Journal of Sociology* 39(1): 62-81.

Nakhaie, M. Reza. 2002. "Gender Differences in Publication Among University Professors in Canada." *Canadian Review of Sociology and Anthropology* 39(2): 151-180.

Natriello, G. 2001. "Comment: Bridging the Second Digital Divide: What Can Sociologists of Education Contribute?" *Sociology of Education* 74: 260-265.

Nederveen Pieterse, Jan. 2004. *Globalization and Culture : Global Mélange.* Lanham, MD: Rowman and Littlefield Publishers.

Nie, N. H. and Erbring, L. 2000. "Internet and Society: A Preliminary Report." Online at http://www.stanford.edu/groups/siqss/.

Nie, N. H., D. S. Hillygus, and L. Erbring. 2000. "Internet Use Interpersonal Relations and Sociability: A Time Diary Study." In *The Internet in Everyday Life*, edited by B. Wellman and C. Haythornthwaite. Malden, MA, USA, Blackwell.

Oman, Charles. 1993. "Globalization and Regionalization in the 1980s and 1990s." *Development & International Cooperation* 9(16): 51-69.

Ono, H., and M. Zavodny. 2003. "Gender and the Internet." *Social Science Quarterly* 84(1): 111-121.

Palackal, Antony, Meredith Anderson, B. Paige Miller, and Wesley Shrum. 2006. "Gender Stratification and E-Science: Can the Internet Circumvent Patrifocality?" In *New Infrastructures of Knowledge Production: Understanding E-Science,* edited by Chrstine Hine. Idea Group Publishing.

Parayil, Govindan. 2005. "Digital Divide and Increasing Returns: Contradictions of Informational Capitalism." *The Information Society* 21(1).

Patterson, Rubin and Ernest J. Wilson, III. 2000. "New IT and Social Inequality: Resetting the Research and Policy Agenda." *The Information Society* 16(77): 77-86.

Poverty Reduction and Economic Management Network (PREM). 2002. *Empowerment and Poverty Reduction: A Sourcebook*. Washington DC: The World Bank.

Quan-Haase, Anabel and Barry Wellman. 2002. "How Does the Internet Affect Social Capital." In *IT and Social Capital*, edited by Marleen Huysman and Volker Wulf.

Ramachandran, Vimala. 1998. "Engendering Development: Lessons from the Social Sector Programmes in India." *Indian Journal of Gender Studies* 5(1): 49-63.

Reskin, Barbara F. 1977. "Scientific Productivity and the Reward Structure of Science." *American Sociological Review* 42: 491-504.

Reskin, Barbara F. 1993. "Sex Segregation in the Workplace." *Annual Review of Sociology* 19: 241-270.

Reskin, Barbara F., Debra B. McBrier, and Julie A. Kmec. 1999. "The Determinants and Consequences of Workplace Sex and Race Composition." *Annual Review of Sociology* 25: 335-361.

Ridgeway, Cecilia. L. 1997. "Interaction and the Conservation of Gender Inequality: Considering Employment." American Sociological Review 62(2): 218-235.

Ridgeway, Cecilia L., and Lynn Smith-Lovin. 1999. "The Gender System and Interaction." *Annual Review of Sociology* 25: 191-216.

Ridgeway, Cecilia and Shelley J. Correll. 2004. "Unpacking the Gender System: A Theoretical Perspective on Cultural Beliefs and Social Relations." *Gender and Society* 18: 510-531.

Ritzer, George. 1993. *The McDonaldization of Society*. Newbury Park: Pine Forge Press.

Robertson, Roland. 2000. "Globalization Theory 2000+: Major Problematics." *Handbook of Social Theory*. Thousand Oaks, CA: Sage Publications.

Rodrik, Dani. 2000. "Has Globalization Gone Too Far?" Pp. 221-227 in *The Globalization Reader*, edited by Frank J. Lechner and John Boli. Malden, MA: Blackwell Publishers.

Rogers, Everett M. and D. Lawrence Kincaid. 1981. *Communication Networks: Toward a New Paradigm for Research*. New York: The Free Press.

Rostow, Walt W. 1960. *The Stages of Economic Growth: A Non-Communist Manifesto*. Cambridge: University Press.

Schech, Susanne. 2002. "Wired for Change? The Links Between ICTs and Development

Discourses." *Journal of International Development* 14(1): 13-23.

Schiebinger, Londa. 1999. *Has Feminism Changed Science?* Cambridge, MA: Harvard University Press.

Schofer, Evan, Francisco O. Ramirez, and John W. Meyer. 2000. "The Effects of Science on National Economic Development, 1970-1990." *American Sociological Review* 65(6): 866-887.

Schofer Evan. 2004. "Cross-national Differences in the Expansion of Science, 1970-1990." *Social Forces* 83 (1): 215-248.

Scholte, Jan Aart. 2000. *Globalization: A Critical Introduction*. Palgrave Macmillan.

Schott, Thomas. 1993. "World Science: Globalization of Institutions and Participation." *Science, Technology and Human Values* 18: 196-208.

Schwanen, Tim and Mei-Po Kwan. 2008. "The Internet, Mobile Phone, and Space Time Constraints." *Geoforum* 39: 1362-1377.

Scott, John P. 1991. *Social Network Analysis*. London: SAGE Publications.

Shahidullah, Shahid M. 1991. *Capacity-Building in Science and Technology in the Third World: Problems, Issues, and Strategies*. Oxford: Westview Press.

Shapin, Steven. 1995. "Here and Everywhere: Sociology of Scientific Knowledge." *Annual Review of Sociology* 21: 289-321.

Sheffield, Suzanne Le-May. 2004. *Women and Science: Social Impact & Interaction*. Rutgers University Press.

Shih, E.C. and A. Venkatesh. 2004. "Beyond Adoption: Development and Application of a Use-Diffusion Model." *Journal of Marketing* 68(1): 59-72.

Shrum, Wesley. 1997. "View From Afar: 'Visible' Productivity of Scientists in the Developing World." *Scientometrics* 40: 215-235.

—. 1997. "A Social Network Approach to Research Systems for Sustainable Agricultural Development: Results from a Study of Kenya, Ghana, and Kerala." International Service for National Agricultural Research, briefing paper #36.

—. 2005. "Reagency of the Internet, or, "How I Became a Guest for Science." *Social Studies of Science* 35(5): 723-754.

Shrum, Wesley and Carl Bankston. 1993. "Organizational and Geopolitical Approaches to

International Science and Technology Networks." *Knowledge and Policy* 6.

Shrum, Wesley and John J. Beggs. 1996. "A Methodology for Studying Research Networks in the Developing World: Generating Information for Science and Technology Policy." *Knowledge and Policy* 9: 62-85.

Shrum, Wesley and Patricia Campion. 2000. "Are Scientists in Developing Countries Isolated?" *Science, Technology, and Society* 5:1-34.

Shrum, Wesley and Nicholas Mullins. 1988. "Network Analysis in the Study of Science and Technology." In *The Handbook of Quantitative Studies of Science and Technology,* edited by A.F.J. Van Raan. North Holland: Elsevier Science Publishers B.V.

Shrum, Wesley and Yehouda Shenhav. 1995. "Science and Technology in Less Developed Countries." Pp. 229-256 in *Handbook of Science and Technology Studies,* edited by S. Jasanoff, G.E. Markle, J.C. Petersen and T. Pinch. Thousand Oaks, CA: Sage Publications.

Singer, J. D. and J. B. Willett. 2003. *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence*. Oxford: University Press.

Sklair, Leslie. 2000. " Sociology of the Global System." Pp. 64-70 in *The Globalization Reader,* edited by Frank J. Lechner and John Boli. Malden, MA: Blackwell Publishers.

Smith-Lovin, Lynn and J. Miller McPherson. 1993. "You are Who You Know: A Network Perspective on Gender." Pp. 223-51 in *Theory on Gender/Feminism on Theory*, edited by Paula England. New York: Aldine.

Snyder, Margaret and Mary Tadesse. 1995. *African Women and Development*. Johannesburg: WUP.

Sonnert, Gerhard, Mary Frank Fox, and Kristen Adkins. 2007. "Undergraduate Women in Science and Engineering: Effects of Faculty, Fields, and Institutions Over Time." *Social Science Quarterly* 88(5): 1333-1356.

Stehr, Nico. 2001. "Modern Societies as Knowledge Societies." In *Handbook of Social Theory,* edited by G. Ritzer and B. Smart. London: Sage Publications.

Stiglitz, Joseph E. 2002. *Globalization and its Discontents*. New York and London: WW Norton.

Uimonen, Paula. 2001. *Transnational Dynamics@Development.net: Internet, Modernization and Globalization*. Stockholm, Sweden: Elanders Gotab.

United Nations Conference on Trade and Development Information Economy Report. 2007.

Science and Technology for Development: The New Paradigm of ICT. New York: United Nations Publications.

Venkatesh, V., M.G. Morris, G. B., and F. D. Davis (2003). "User Acceptance of Information Technology: Toward a Unified View." *MIS Quarterly* 27(3): 425-478.

Wagner, Caroline S. 2008. *The New Invisible College: Science for Development*. Brookings Institution Press.

Wajcman, Judy. 1991. *Feminism Confronts Technology.* University Park, PA: The Pennsylvania State University Press.

—. 1995. "Feminist Theories of Technology," In *The Handbook of Science and Technology Studies,* edited by S. Jasanoff, G.E. Markle, J.C. Peterson, and T. Pinch. Thousand Oaks, CA: Sage Publications.

—. 2007. "From Women and Technology to Gendered Technoscience." *Information, Communication, and Society* 10(3): 287-298.

Walby, Sylvia. 2000. "Analyzing Social Inequality in the Twenty-First Century: Globalization and Modernity Restructure Inequality." *Contemporary Sociology* 29: 813-818.

Wallerstein, Immanuel. 1974. *The Modern World System*. New York, NY: Academic Press.

Wallerstein, Immanuel. 2005. "After Developmentalism and Globalization, What?" *Social Forces* 83: 1263-1278.

Warschauer, Mark. 2003. *Technology and Social Inclusion: Rethinking the Digital Divide.* Cambridge, MA: MIT Press.

Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis: Methods and Applications: Structural Analysis in the Social Sciences*. Cambridge University Press.

Wellman, Barry. 1983. "Network Analysis: Some Basic Principles." *Sociological Theory* 1: 155-200.

—. 1985. "Domestic Work, Paid Work and Net Work." Pp. 159-91 in *Understanding Personal Relationships,* edited by Steve Duck and Daniel Perlman. London: Sage.

—. 1988. "Structural analysis: From method and metaphor to theory and substance." Pp. 19-61 in *Social Structures: A Network Approach,* edited by B. Wellman and S.D. Berkowitz. Cambridge: Cambridge University Press.

—. 2001. "Computer Networks as Social Networks." *Science* 293(14): 2031-34.

Wellman, Barry, Anabel Quan Haase, James Witte, and Keith Hampton. 2001. "Does the

Internet Increase, Decrease, or Supplement Social Capital?" *American Behavioral Scientist* 45(3): 436-455.

Wellman, Barry, Emmanuel Koku, and Jeremy Hunsinger. 2006. Pp. 1429-1447 in *The International Handbook of Virtual Learning Environments*, edited by J. Weiss et al. Holland: Springer.

Wellman, Barry, Janet Salaff, Dimitrina Dimitrova, Laura Garton, Milena Gulia, and Caroline Haythornthwaite. 1996. "Computer Networks as Social Networks: Collaborative Work, Telework, and Virtual Community." *Annual Review of Sociology* 22: 213-238.

Wilson, M. 2003. "Understanding the international ICT and development discourse: assumptions and implications." *The Southern African Journal of Information and Communication*, available at: http://link.wits.ac.za/journal/j0301-merridy-fin.pdf accessed 1 May 2009.

Xie, Yu and Kimberlee A. Shauman. 2003. *Women in Science: Career Processes and Outcomes*. Cambridge, MA: Harvard University Press.

Yearley, Steven. 1988. *Science, Technology and Social Change*. London: Unwin Hyman.

Yearley, Steven. 2005. *Making Sense of Science: Understanding the Social Study of Science*. London: Sage Publications.

APPENDIX: LIST OF ORGANIZATIONS AND RESEARCH INSTITUTES SAMPLED

KERALA	KENYA	GHANA
Kerala Agri. Univ. Vellayani:	**Egerton Univ.**	**Science & Technology Policy Research Institute**
Dept. Agronomy	Dept. of Agronomy	Council for Scientific & Industrial Research (CSIR)
Dept. Agri. Botany	Dept. of Horticulture	Food Research Institute
Dept. of Agri. Economics	Dept. of Zoology	Water Research Institute
Dept. of Agri. Statistics	Dept. of Animal Sciences	Industrial Research Institute
Dept. of Home Science	Dept. of Agricultural Economics	Animal Research Institute
Dept. of Plant Pathology	Dept. of Botany	Crop Research Institute
Dept. of Soil Science & Ag Chem	Dept. of Food Nutrition & Characteristics	Soil Research Institute
Dept. of Plant Physiology	Dept. of Natural Resources	Printing & Publishing
Dept. of Animal Husbandry	Dept. of Industrial Energy Engineering	Science & Publishing/Information Technology (INSTI)
Dept. of Ag Engineering	Dept. of Soil Science	Building & Road Research Institute
Dept. of Plant Breeding & Genetics	Dept. of Dairy & Food Technology	Noguchi Memorial Inst. for Medical Research
Dept. of Horticulture	Dept. of Chemistry	**University of Ghana Legon (UGL)**
Extension	Dept. of Environmental Science	Dept. of Crop science
Vellanikkara: Dept of Agricultural Ext.	**Univ. of Nairobi**	Dept. of Agric Economics
Univ. of Kerala	Dept. of Zoology & Botany	Dept. of Botany
Dept. of Botany	Dept. of Animal Production	Dept. of Soil science
Dept. of Aquatic Biology & Fish	Dept. of Crop Sciences	Dept. of Geology
Dept. of Zoology	Dept. of Geography	Dept. of Animal science
Dept. of Biochemistry	Dept. of (Veterinary) Clinical Studies	Dept. of Zoology
Dept. of Chemistry	Dept. of (Veterinary) Pathology & Microbiology	Dept. of Biochemistry
Dept. of Geology	Dept. of Geology.	Dept. of Physics
Dept. of Computer Science	Dept. Public Health	Dept. of Chemistry
Dept. of Physics	**Kenya Agri. Research Institute**	Dept. of Agric Engineering
Dept. of Biotech	National Agric Res Labs (Kabete)	Dept. of Fisheries & Oceanography
CSIR:	National Agric Res Centre (Muguga)	Dept. of Agricultural Extension
Regional Research Laboratory	National Vet Res Cent (Muguga)	Dept. of Home science
Centre for Earth Science Studies	Thika – Nat Horticultural Res Cent	Dept. of Engineering
Central Tuber Crops Research Institute	Katumani Nat Drylands Farming Res Cent	**University of Cape Coast**
	Jomo Kenyatta Univ. of Agri. and Tech.	Dept. of Agric Economics & Extension
	Dept. of Horticulture	Dept. of Crop science
	Dept. of Agricultural Engineering	Dept. of Chemistry
	Dept. of Food Sciences & Post Harvest Tech	Dept. of Animal science
	Dept. of Faculty of Science	Dept. of Geography, Geography & Tourism
	Dept. of Computer Sciences	Dept. of Physics
	Dept. of Biomechnical & Environmental Engineering	Dept. of Centre for Dev Studies
	Dept. of Zoology	Dept. of Agric Engineering
	Dept. of Physics	Dept. of Zoology
	Dept. of Mathematics	Dept. of Botany
	Dept. of Institute of Energy & Environmental Tech.	Dept. of Soil science
	Dept. of Botany	Dept of Science & Mathematics Education
	Dept. of Biochemistry	Dept of Molecular Biology/Biotechnology
	Dept. of Chemistry	Dept. of Biochemistry
	Dept. of Mechanical Engineering	
	Dept. of Agricultural Engineering	

VITA

Dr. Beverly Paige Miller grew up in South Dakota. She attended college in Spearfish, South Dakota, where she attained her bachelor's degree in sociology in 2003. She moved to Baton Rouge, Louisiana in 2004 where she pursued her master's and Doctor of Philosophy in sociology at Louisiana State University. While attending LSU, Dr. Miller studied the use of new communication technologies by female researchers in less developed countries. Through this project she has traveled to Ghana and Kerala, India, to assist in data gathering over the summer of 2005 and the summer of 2008. She also assisted in the organization and implementation of the World Summit on the Information Society (WSIS), held in the Fall of 2005 in Tunis, Tunisia. Dr. Miller has received a job offer at the University of Wisconsin, River Falls, where she plans to move in the fall.