Running Head: GENDER STRATIFICATION AND E-SCIENCE

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TITLE
Gender Stratification and E-Science:
Can the Internet Circumvent Patrifocality?

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ABSTRACT

Can the Internet improve the lot of women in the developing world? This study investigates the degree to which the Internet affects the constraints on women pursuing scientific careers. We address this question in the context of the scientific community of Kerala, India, developing a "circumvention" argument that fundamentally implicates information and communication technologies in shaping gender roles. We begin by reviewing two main constraints identified in prior research (educational and research localism) that increase the likelihood of restricted professional networks. Next, we examine the extent to which women scientists have gained access to e-science technologies. With evidence of increased access, we argue that the presence of connected computers in the home has increased consciousness of the importance of international contacts. We conclude by proposing that Internet connectivity is helping women scientists to circumvent, but not yet undermine, the patrifocal social structure that reduces social capital and impedes career development.

INTRODUCTION

E-science technologies have been widely heralded as an equalizer for communities of knowledge workers remote from global scientific centers. They promise to promote development by decreasing the cost and increasing the efficiency of both international and local communication, improving access to information and facilitating international collaboration. Davidson et al. (2002) refer to such arguments promoting the Internet as an "elixir" that will heal developmental woes. What is missing throughout most of this discussion is gender, particularly in reference to the issue of whether the Internet differentially affects men and women scientists. Likewise, throughout the vast literature on sex differences in scientific attainment (Cole & Zuckerman 1984, 1987; Fox, 1995; Fox & Long, 1995;; Keller, 1995; Kyvik & Teigen, 1996; McElrath, 1992; Mukhopadhyay, 1994; Ranson, 2003; Wajcman, 1991, 1995; Xie & Shauman, 1998), the impact of new information and communication technologies on the careers of female scientists has largely been neglected.

The main objective of this essay is the examination of qualitative evidence for a specific idea regarding the relationship between gender inequity and e-science technologies under the social structural conditions of patrifocality that characterize most of the Indian subcontinent. We propose that Indian women scientists have begun to use the Internet to circumvent gender codes that govern behavior and limit access to social capital, particularly international professional contacts. The consequences of an affirmative answer would be significant for two reasons. First, since enhanced connectivity and access to the Internet might then be expected to reduce gender inequities in the knowledge sector. But perhaps more important, what might now be simple

technological leverage could begin a process that would undermine the broader social structure of patrifocality.

We develop this argument through an examination of ninety qualitative interviews with agricultural and environmental scientists in Kerala, India. The main purpose is to explore the Internet as an equalizing mechanism for women in science in view of major constraints on the development of social capital previously identified as limiting career trajectories for women in Africa and India. We begin by considering gender inequality and the social structural context of patrifocality in the Indian context. We summarize prior work on Kerala women scientists and the characteristics of educational and organizational localism that constrain the development of social capital. Following a description of our methodology, we introduce evidence that women scientists are still highly constrained in their educational and subsequent work experiences. However, qualitative evidence seems to suggest two social changes are occurring: (1) dramatic improvement in access to new information and communication technologies, (2) the importance of international professional ties are becoming part of feminine consciousness. In the last section of the paper we discuss the implications of these findings in relation to the broader gender structure and maintain that the increasingly common presence of women in the Indian labor force is also functioning to undermine the stringent system of gender stratification.

SCIENCE AND GENDER INEQUALITY

One of the few empirical studies to address the conditions of women scientists in India and Africa is Campion and Shrum's analysis of 293 scientists in Kenya, Ghana, and

Kerala (India). Based on data gathered in 1994, when connections to the Internet were still extremely rare, this study addressed the question: Why do women in the developing world have more difficulty pursuing research careers than their male counterparts? Through the analysis of gender differences in educational and personal backgrounds, research productivity, professional activities, organizational resources, and professional networks, as well as the consequences of these differences, they argued that gender inequality results from a lack of social rather than material resources. On a great variety of indicators, gender differences are not large, but rather trivial or nonexistent. Yet in comparison to their male colleagues, female scientists in Kerala were found to possess disadvantages in terms of participation rates on government committees and editorial boards, publications in international journals, and contacts outside of the local research system, including those with professionals in developed countries. Overall, the networks of male scientists were found to have broader range than those of their female counterparts, leading the authors to suggest that more international opportunities for women should be made available.[i] Our study begins with this background and examines questions of technological and social change, for what has happened in the decade since 1994 is a major shift in the way science is conducted, owing to the widespread diffusion of the Internet.

Inequities in the Indian scientific community result from a stringent system of gender roles, combined with the ethnocentric tendency for modeling research careers on those of the developed world (Campion and Shrum, 2004). Subrahmanyan noted that much of the existing literature on the masculine nature of science and the resulting instances of particularism are based on western experiences and social order (1998).[ii]

One reason career advancement is problematic in the Indian academic sector is a quota system based on caste. Promotion considerations are based partly on merit, but often a qualified individual of the appropriate caste must fill a faculty vacancy in order to maintain the prescribed balance within each department. For this reason, university careers often stagnate regardless of individual achievements. Caste issues affect both men and women.

Our focus here is a second overarching feature of the Indian system, which has been described as "patrifocality." While extended discussions may be found in Mukhopadhyay and Seymour (1994) and Subrahmanyan (1998), the significant features are summarized by Gupta and Sharma in their analysis of Indian women scientists:

> subordination of individual interests to the welfare of the family; gender-differentiated family roles with females being associated with the 'private' sphere; gender differentiated family authority structure (with authority of same-generational males over socially equivalent females, such as husbands over wives, brothers over sisters); family control of marriage arrangements; patrilineal descent, inheritance, and succession; patrifocal residence, with daughters shifting allegiance to husband's family after marriage; and an ideology of 'appropriate' female behaviour that emphasizes chastity, obedience, and modesty (2002: 902).

Patrifocality denotes a general set of social structural characteristics that tend to appear together in the Indian social context. To say that a system is patrifocal is not to say that it is without variability, nor is it to say that all of its features are inextricably tied together. For example, in the State of Kerala, the focus of our study, matrilocal residence is not uncommon, but patrifocality still describes the social structural conditions that obtain.

For our purposes, the central point is that for Indian women scientists, the patrifocal system involves an extreme commitment to localism, restricting interactional opportunities out of micro-level familial concerns for the purity and labor of females. In brief, (1) women should first attend to their caretaking obligations, and (2) their movements out of the household should ordinarily be limited to those required for the fulfillment of those duties. The social limitations implied by patrifocality are clearly pronounced. Gender inequity in educational, travel, and work opportunities results in lower access to social capital and embedded network resources (Lin, 2001).

Campion and Shrum's evidence in the specific context of Kerala is part of a broader set of concerns with women's social networks. Gupta and Sharma (2002) maintain that the social networks of Indian women scientists are limited for several reasons. First, their networks are basically gender homophilous due to social segregation in which informal interaction with unrelated men is problematic. Second, their networks are more locally oriented due to cultural constraints upon their geographic mobility. Finally, they lack female mentors and colleagues with whom they can safely collaborate. For these reasons, Indian women are likely to be professionally isolated. As one academic chemical engineer articulates: "'I am the only woman in the department. It has a male culture. Men have their own tea clubs. I feel different and isolated. The colleagues talk very little with me'" (2002: 907).

In this sense, female scientists can be seen to possess a lower degree of social capital than their male counterparts, for their network ties are usually homophilous by sex. Smith-Lovin and McPherson (1993) theorize basic processes by which homophilous networks ensue from a lifetime of socialization. While their work is focused on

developed countries, network theory can be employed generally to explain "how small, seemingly inconsequential differences between males and females in childhood or early adulthood can be transformed over the life course into dramatic levels of gender segregation and inequality" (1993: 223). Gender homophilous ties to childhood playmates coupled with tendencies to respond differently to network structures result in dissimilar social realities, and therefore different locations in the social structure, for girls and boys during their formative years. Women tend to occupy network positions that facilitate the flow of information about the private sphere of household and family while those of men contain resources that promote upward mobility in the public sphere of career and finance. Ultimately, networks of adult women become densely connected and contain more ties to kin and neighbourhood, while networks of adult men are sparser but more extensive, containing more ties to co-workers and outside members. We focus on the consequences of this process in the distinctive context of the Indian system of gender stratification. Our work centers on the distinction between face to face contact and electronic communication and information flows made possible by the Internet. While we find it premature to regard social change as extensive—indeed, specific evidence continues to be hard to find—we examine the degree to which women scientists have begun to use electronic communication to circumvent patrifocal interactional restrictions, gaining increased access to social networks and social capital.

THE KERALA CONTEXT

The state of Kerala in southwestern India has long been a focus of attention for the Indian and international development communities. Initially, Kerala garnered renown

owing to its unique political and socio-cultural history: for instance, the first elected Communist government in the world and matrilineal kinship organization among dominant communities like the Nayars. More recently, interest has been focused on its paradoxical pattern of growth, often referred to as the "Kerala Model of Development," characterized by high social achievements on a weak economic base (George, 1993; Oommen, 1992, 1999; Ramachandran, 1996; Shrum and Iyer, 2000). In the context of the growing incidence of crimes against women, coupled with rising rates of suicide and mental illness, serious doubts have arisen regarding the widely publicized high status of women in Kerala as measured by conventional indicators like literacy and sex ratio. However, within Indian feminist literature, the concept of 'status' itself has been criticized as failing to recognize the unequal relations of power between men and women in a society that situates women in an inferior position inside and outside the private sphere (Saradamoni, 1994). Our analysis must be sensitive to these unique conditions. Nonetheless, it is appropriate to ask whether, given the restrictions patrifocality places on women in Kerala as well as other Indian state, new information and communication technologies are affecting gender inequities. Can the Internet be regarded as an equalizer?

METHODOLOGY

We base the circumvention argument on 90 face-to-face interviews conducted in Kerala between 2003 and 2004 with professional scientists in a variety of fields, emphasizing agriculture, environment, and natural resource management. Our informants worked in four scientific organizations (two research institutes and two

universities) in or near Thiruvananthapuram, the capital. One of the research institutes operates under the auspices of the central government in New Delhi, while the other is an agency of the state government in Kerala. The size of the two universities required us to select a subset of departments in the agricultural and basic scientific fields. One institution focused almost exclusively on agricultural training, while the other was more comprehensive. We sought interviews with all active scientific staff in the institutes but selectively oversampled women in the universities. This sampling strategy does not allow us to generalize to the entire population of scientists in Kerala. However, it does allow us to explore in detail the ways in which the Internet is beginning to affect the scientific community in the context of gender roles.

From 1994 to 2000 the proportion of women scientists in Kerala has remained relatively constant: slightly more than one third, or 37% in 2000 (Sooryamoorthy and Shrum, 2004).[iii] Out of 90 respondents from the four organizations, approximately one quarter were women. The national research institute employs a much higher proportion of women than the state institute, where we could speak with only two women. Men comprised a disproportionate number of respondents in all locations. While the percentage of women working in the professional field of science is not equal to that of men, it is much higher than in many developing areas.[iv]

Interviews were preceded by the review of each respondent's curriculum vitae and recent publications. Interviews were transcribed and imported into QSR NVivo, a software package designed for the analysis of qualitative data. The primary use of the software was for thematic coding, which allowed the data to be analyzed using Boolean searches, locating passages possessing a feature or combination of features such as

intersections or unions (Richards, 1999). The themes or "nodes" were coded according to the scheme summarized in Appendix A. For this analysis, we utilized seven "parent" nodes: Location of Higher Education, Organizational Involvement, Visits Abroad, Professional Contacts, Internet Use and Access, Research Related Email Transactions, and Gender Discourse. Each parent node was coded into a number of "child" nodes, which served to organize responses in terms of the diffusion of Internet technologies and their impact on female scientists' access to social resources. Searches of the coded interviews were conducted using these nodes, categorized by the sex of the respondent. In what follows we first consider the two sources of localism, education and travel, previously identified as constraints on social capital. Next, we examine connectivity and access to the Internet by men and women scientists, including the role of the computer in the domestic setting. We then turn to the question of professional networking and role circumvention.

HIGHER EDUCATION

The extent and location of higher education are important indicators of gender inequity within the scientific communities of the world. To the extent that women do not have the same level of training as men, and to the extent that they do not have access to the same places[v] of training as men, gender differences will persist with respect to the human and social capital necessary for the pursuit of scientific research and careers. Sooryamoorthy and Shrum (2004) showed that within the community of agricultural and environmental scientists of Kerala, the percentage of doctorates remained approximately constant from 1994 to 2000. However, our unpublished data shows that women have

made significant gains during the same period. While the proportion of males with Ph.D.'s went down from 89% to 78%, the proportion of women with doctorates rose from 67% to 76%. While some of this difference—particularly the lower proportion of male Ph.D.'s—may be the result of alternative sampling strategies (described in Sooryamoorthy and Shrum, 2004), the increase in female educational qualification is likely to represent real gains.[vi]

Location of doctoral degree represents, in a stark sense, opportunity: opportunities to develop social capital, to receive training unavailable in Kerala, to broaden scientific horizons, and finally, to acquire prestige. Using 1994 data, Campion and Shrum, found that male scientists in the developing world were more likely to receive training in developed countries, specifically in the United States and Europe, and spent more time abroad for training and education. However, Indian scientists were less likely to receive advanced training abroad than their African counterparts. Sooryamoorthy and Shrum showed that in 2000, only about 1 in 20 scientists from these institutions received their training in a developed country. Generally, training "outside" Kerala means education in Tamil Nadu or other locations in the Indian subcontinent.

In our qualitative interviews, we examined the persistence of these patterns. All of the academic faculty we interviewed possessed the Ph.D. degree. However, women were slightly more likely to possess doctorates than men within the government research institutes. The reason is not that women are more highly educated in the Kerala context, but that the state research institute, which employs the fewest doctorates, is also the most likely to employ men.

Our analysis of the location of highest degree, and particularly for doctoral studies, indicates that women scientists were more likely to be constrained in terms of location. In comparison to men, they were less likely to receive their degrees from universities outside Kerala. Many female respondents echoed similar sentiments in regard to limited mobility and the barriers placed on them in choosing to pursue higher studies. The vast majority of women completed their higher degrees, and in many cases all of their degrees, within the state of Kerala. One Head of Department described her situation as follows:

> We cannot move out freely after the household chores. My husband is not the kind who is supportive {...} My husband is very orthodox. He would get irritated with studying after marriage. He wanted me to have job but did not like me studying after marriage.

Only one woman received a foreign doctorate. In this rare case, she resided in South Korea for three years while her husband and child remained in India.

Women scientists did not generally aspire to foreign degrees—it was simply not part of their thinking. On the contrary, many Indian women reported beginning their doctoral studies as a result of having no definite career plans, or beginning studies only after procuring permission from their husbands. The situation of male scientists is quite different. For men, choice of location of higher education seemed to be a non-issue. Their mobility was uninhibited, allowing them to enroll in the institution of their choice. No male respondent spoke of turning down opportunities to study abroad due to family

concerns. On the other hand, one woman recalled interrupting her studies when her husband accepted a fellowship in Canada. When women went abroad, usually their male partners or siblings first undertook foreign assignments and the women, as wives or sisters, accompanied them. Women simply did not make independent decisions to go abroad for studies—educational decisions were inextricably linked to the decisions of other family members.

We conclude that while there are not important differences in the level of training between men and women, the location of higher education (especially the doctorate) was fundamentally constrained by marital and domestic considerations. This "educational localism" is consistent with studies by both Gupta and Sharma (2002) and Campion and Shrum (2004). Listening to the stories of women scientists, it seemed clear that women were not in a position to independently choose an academic center for their higher learning, especially after marriage. As most women in southern India are married around the age at which they complete their Master's degree, they generally undertake higher degrees with little or no intention of building a career or pursuing one that would detract from their family responsibilities. Gender roles, marital values, and family obligations impinge on "centrifugal" movements (away from family), serving as a set of normative and functional restrictions. Far from a state of equality, the stratified socio-cultural milieu of Kerala is such that men have relative freedom of choice, leading to geographic mobility in educational outcomes. For women such freedom is incidental to familial ideology and requirements. Additionally, the element of safety in an alien geographical environment is viewed as an important consideration involved in choosing the location of

higher education (Gupta and Sharma, 2002). For this reason, women tend to secure the company of a male spouse or relative before considering study outside of India.

Although these observed trends are not surprising, given the patrifocal social context of India, their implications are especially important to understand in the new context of e-science technologies. Since some Internet users receive their computer training in the developed world, women can be seen as possessing an additional disadvantage. Not only are they more likely to receive all of their training from the same institution, limiting their exposure to new approaches and ideas, they are also less likely to benefit from training in the technologically savvy institutions of the west. Furthermore, both male and female respondents who studied or trained outside of India reported that their professional and personal contacts in these countries remained strong and that these individuals continued to serve as partners in collaboration, providers of much needed resources, and friends.[vii] In this sense, a locally oriented education serves to limit one's access to both social and material resources.

TRAVEL

The second constraint on social capital identified by Campion and Shrum is the gender difference in time spent away from the employing organization (2004). This variety of localism is organizational or "research" related. It is not that women never leave their organizations for workshops, conferences, training, and research, but that they spend less time doing it—an average of two weeks less per year. As in educational localism, this results in reduced opportunities for the development of professional linkages that may be important to the scientific career.

Notwithstanding constraints resulting from the patrifocal value system, many female scientists in 2003-2004 have undertaken multiple short-term visits abroad. Most of the senior women scientists and professors who were our informants had traveled abroad for career related activities including short term training programs, conferences, workshops, seminars, and symposia. Women from the government research institutes tended to undertake more foreign visits than did their university counterparts. This observed trend appears to result from the greater tendency of government research institutions to send their employees abroad for training rather than individual motivation. Paper presentations at academic seminars or conferences, particularly those at the international level, were regarded as especially important for career advancement. These international opportunities are more plentiful than those that involved in teaching or conducting research abroad. More important, they are brief, which is extremely significant in a context where the domestic labor of women is tightly controlled. Women are much more likely to accept opportunities to visit foreign centers of training when they do not involve extended absences.

In contrast to their female counterparts, most men had undertaken foreign visits, often multiple visits, and these trips tended to last for longer periods of time. Furthermore, more male scientists engaged in foreign travel for the purpose of post-doctoral fellowships, research, and employment than their female colleagues. Women scientists, however, tended to conduct visits abroad quite differently, and were found to participate only in the academic program for which the visit was organized, returning to their families immediately afterwards. Male scientists, on the other hand, often took time off for other academic and non-academic activities when embarking on short-term

international travel. In light of the relatively continuous familial obligations of the patrifocal social milieu of Kerala, women are likely to attend conferences, workshops, and other short meetings, and less likely to undertake training, collaboration, or research projects that would require extended absences from the domestic setting.

These interviews lead us to conclude that the high priority of family obligations affects the frequency, type, and duration of visits abroad for Indian women scientists. Campion and Shrum found that male scientists traveled more extensively, arguing that they were therefore more likely to gain exposure to international standards and practices of research (2004). In the earlier time period, nearly half the women in their sample had no experience at all in a foreign country. Our qualitative interviews ten years yielded little evidence of change: a slight majority of respondents reported at least one visit to the developed world for the purpose of research or training. The frequency may have increased, but what seems stark is the evidence for increased consciousness of the importance of travel.

The importance of travel for Indian scientists cannot be overemphasized, for these visits often result in the creation of network ties with scientists in the developed world. In turn, these ties can later serve as a source of the social and material resources necessary to provide information and enhance productivity. But we note that contacts in the developed world can also be seen to benefit Indian women scientists in another way—in the global scientific community, individuals are less likely to subscribe to the patrifocal ideology that restricts contact between unrelated men and women. The cultivation of these contacts is extremely important to the career of Indian women scientists. But if women are still unable to travel outside the organization apart from

infrequent and brief periods, then they are denied the opportunity to develop ties that can effectively subvert patrifocal restrictions on their behavior. As with educational localism, organizational localism based on a duality of self- and socially-imposed restrictions, restricts the face-to-face interactions that have traditionally led to increases in the size and range of scientific networks. The question, then, is whether electronic interactions provide a way of circumventing these restrictions.

CONNECTIVITY AND ACCESS

E-science technologies are all based on the assumption that researchers are connected to the Internet. But as a forthcoming study by Ynalvez et al. shows, in the context of developing areas (2005), Internet connectivity is anything but an unproblematic concept: while the vast majority of scientists describe themselves as current email users, far fewer have personal computers, ready access to the technology, use it in diverse ways, or have extensive experience. In brief, Internet "adoption" cannot be characterized as a single act on the part of users. Computer access, bandwidth, technological privacy, and the skill required for the effective use of e-science technologies are equally important for scientific research and careers.

One definition of adequate connectivity that has been employed in developmental arguments is a dedicated computer system for each scientist, with relatively high connection speeds, and adequate maintenance, that is, brief periods of downtime (Shrum, 2005). This e-scientific environment is the standard for Western scientists—indeed, it is assumed by most scientists, explicitly or implicitly, when they consider or engage in collaboration across national boundaries.

It was quickly apparent that government research centers were much better provided for in terms of Internet connectivity than academic scientists. This finding is consistent with our quantitative assessments of the Kerala research system (Sooryamoorthy and Shrum, 2004; Ynalvez et al. 2005) and it rapidly became a crucial point in our understanding of e-science in Kerala. The disparity between governmental research centers and academic institutions in terms of Internet connectivity was pronounced. While both sectors reported the existence of Internet connections, only those respondents employed at the two research centers felt they had adequate access to the Internet at work. In these locations, there were generally two to three computers in each lab. Respondents often shared computers and many did not claim to have an exclusive connection at work. Both research centers expressed satisfaction with the LAN connections recently acquired by their institutes, but those working at the national institute did complain about the lack of access outside of office hours, which required special permission.

> Although the connectivity is for 24 hours but we are able to access it only till office hours. At 3.30 in the afternoon…they switch off the main server. Because there are occasions when you need to use it even after office hours- a couple of hours more.

While this may be perceived as a disadvantage, it is more likely to result in gender equity than inequity, since restrictions on the movement of women largely prevent them from working during non-standard hours—they have fewer opportunities than men to use the facilities outside of the normal working period.

University faculty encountered other issues. Although most have come to terms with the present arrangement of Internet facilities, there are simply too few computer systems available to the staff. The number of computers connected to the Internet varied by department, rarely exceeding two or three machines. As Ynalvez et al. report (2004), nearly thirteen individuals shared a single computer in the Kerala academic sector in the year 2000, the highest average in a study that included Ghana and Kenya. While many respondents felt that they would acquire additional connections within the near future, over the five years since we began work there progress has been extremely slow. Not only are there few machines, but their presence in a nonrestricted academic environment has an inevitable consequence: university scientists also had to cope with the fact that students generally monopolized existing connections. According to one marine biologist, "Here in the department only one computer is connected to the Internet. So all the students will be crowding around that all the time…teachers don't go and use it during office hours."

Although Internet access was available in the libraries and computer labs of both universities, faculty rarely used it, owing to the number of machines and competition with students. The speed and reliability of connections was another common complaint, since many of departments still rely on dial up connections over undependable telephone lines. This put scientists at a particular disadvantage with respect to downloading the large files sometimes needed for data manipulation or literature review. In sum, a situation exists in which universities have devolved the responsibility for connectivity to the faculty themselves. If they are to use ICTs in a significant way for research and teaching purposes, they must purchase their own computer and provide for a connection.

However, it was apparent that the costs are sufficiently low and the demand sufficiently high that nearly all university scientists obtained connections at their homes, where they carried out the majority of their communication and information search activities.

As we consider the domestic use of ICTs to be critical to gender issues, it is important to stress the role of the connected computer within the home and familial setting, where sharers of a single computer are only one quarter as many as they are at work (from 12.7 to 3.2) and parents have authority over its use. The clear majority of scientists in both universities and government research institutes claimed that the Internet was a useful tool for professional and personal communication as well as research. Many also spoke of the improvement in the quality of Internet connections available in Kerala and most reported regular use and at least basic knowledge of email and literature searching. Where did they acquire this knowledge? Many learned the Internet from their children—women were especially likely to report this influence of kids. An agricultural chemist began using the Internet in 1999:

> We first bought a computer at home. Then we chat regularly with my husband and my sons are there to help me. Emailing I need only when it is required. But chatting we do….My son [created an account]…Even literature searching he does for me.

The head of a department of plant breeding was asked if anyone was helping her learn the Internet:

> My daughter…and we have [the connection] in our department since about a year…It was difficult as I do not know typing. When I do something when I try to

open or close a window if something happens I would get stuck. My daughter would help me and then I have a relative close to my house who helped me out.

Several men also mentioned the influence of their sons and daughters on the decision to purchase a home computer and the instruction they provided once the system had been installed. Interestingly, the two respondents who claimed to possess the highest degree of knowledge of Internet use, however, were men who gained this knowledge while conducting research in more developed countries.

PROFESSIONAL NETWORKS

The relative disadvantage of women in education and travel should be diminished to the extent that the creation and maintenance of social ties are possible through new ICTs, that is, to the degree that the Internet serves as a functional substitute for face to face contact. In our qualitative interviews, we asked specifically about the professional contacts that were important to these scientists. The answers to these questions did not yield concrete conclusions, but intriguing possibilities regarding what is or may be happening to the professional networks of respondents within the past decade. The baseline is provided by Campion and Shrum's finding that gender inequities are not pronounced for local professional contacts (2004). Especially important is their evidence that (a) women scientists had larger local networks than men in Kerala; and (b) male scientists has more extensive contacts in India, not including Kerala.

Our recent interviews revealed Indian women were quick to mention various professional contacts throughout the world. In comparison with male scientists, Kerala women mentioned far fewer contacts <u>within</u> their departments, and even within India.

Instead, they were far more likely to describe their associations with various international scientists. One noted an instance in which she could continue the professional relationship with a scientist from Madras University whom she had met in a conference. In the course of her professional correspondence with him through email, she recalled, with great sense of pride, approaching him for a fruitful discussion on plant diseases. On another occasion she received a rare sample from an internationally renowned scientist working in a foreign research centre. Following the improvement of connectivity at her institute:

> [My] contact has become a lot, really, otherwise contact was very less. Even when I go for training there also I get some help, otherwise we do not communicate…We have stopped letters. We are ladies, you know, either phone or email, letters are very rare.

This utterance that 'we are ladies' is a loaded phrase in the context of patrifocal structure of Kerala society: the clarity and enthusiasm with which she discussed the use of the Internet for professional networking is revealing of the ways in which electronic communication and is viewed as a social leveller, bringing this younger scientist opportunities she had not experienced.

In contrast, Indian men reported extensively on contacts and collaborations within their departments, institutes, and regional areas. Although Indian women employed in the government sector mentioned more local male contacts than their university counterparts, many of these men occupied supervisory positions and were expected to provide feedback on their work. Similarly, the local male contacts of female respondents were more often identified as lab partners, former professors, or dissertation advisors than scientists who

sought them out on the basis of previous publications or for the purpose of collaboration. Contacts of these types were generally not used for collaboration, but rather for examination purposes or settling questions.

Many female respondents claimed that the Internet was responsible for the cultivation of their international ties. Several mentioned submitting papers to international journals or conferences about which they received information online. Also common were accounts of publishing papers in online journals and subsequently receiving email correspondence from interested readers. In a few cases, such exchanges eventually led to visits abroad and international collaboration. Additionally, nearly all participants in the study claimed that email was their preferred mode of communication with all of their contacts, although some expressed the preference of sending letters by way of post to those professional contacts who were also friends. Overall, the utility of email as a tool to enhance productivity was widely accepted despite the fact that it was also widely held to be more impersonal than communication by telephone or post.

The importance of these findings is that their implication that Indian women in this study are relying more on international contacts than on contacts at the local level. This finding contrasts with those of Campion and Shrum (2003) as well as those of Gupta and Sharma (2002) with respect to the local orientation of Indian women's social networks. Indeed, if confirmed, this would represent a noteworthy change in the nature and pattern of the social networks of Indian women scientists, especially since the patrifocal socio-cultural milieu seems to be firmly in tact. Essentially, women seem to be using the Internet in order to subvert patrifocal regulations on their mobility and behavior. The Internet allows them to create and maintain international network ties to a

greater degree than their male colleagues in spite of their lesser opportunities for international travel.

It is generally assumed that the primary reason external contacts are important is for the exposure to new ideas, information, and international standards and practices of research. This is true regardless of whether the scientist is from the U.S., Africa, or India. But for those embedded in a culture of patrifocality, there are other reasons to value external professional ties. For Indian women, collaboration with male colleagues is often problematic owing to the cultural practices of gender segregation that limit interaction between unrelated men and women to certain kinds of situations. Conversely, professionals in the developing world hold few such beliefs and may be more likely to value the input and experience of Indian women scientists. If we begin to find, as we suspect from these qualitative interviews, that Indian women are relying more heavily on international contacts, it may be because their input is valued more highly by foreign professionals than their own male colleagues. We return to this point in the conclusion.

WOMEN AND WORK

If Internet use has raised consciousness of the importance of international ties, and women are increasing allowed to make short term visits, can this be the beginning of broader social change? That is, can new ICTs be implicated in the subversion of patrifocality? We cannot address this question directly with the available data, but it seems doubtful that the small developments documented here will go *beyond* circumvention to subversion without further increases in the participation of women in scientific careers. Our interviews yielded extensive reports of women in regard to the

historically pervasive limitations on their physical mobility and interactional opportunities. But we want to leave open the possibility that increasing numbers of women pursuing careers in science combined with the ability of the Internet to circumvent many of the social and religious codes that govern their behavior could result in a new reality, at least for women scientists. The Internet itself may allow them to acquire the level of social capital necessary to build a successful career without appearing to violate the social reality of gender stratification.

Despite the existence of widely held social perceptions of women as intellectually inferior, our informants, both men and women, were unanimous that no marked difference exists between the sexes with regard to the quality of academic performance,. In their own experience with students, participants agreed that males and females perform equally well in studies and research. Some respondents even felt that female students fare better academically and are more committed to academic programs than their male counterparts. One senior scientist at the national research institute aired this sentiment, common to the scientific community, regarding the academic performance of female and male students:

> I don't think that there is any conspicuous difference between their programs, particularly in the academic output. Intellectually, both groups are doing well. No difference at that level. When it comes to field activities, because of the practical consideration, boys are in bit more advantageous position – going in ship, cruise, travel etc…

But this level of academic performance does not serve to impress authorities and supervisors with the need to provide equal interactional opportunities for women

scientists that would undermine patrifocal restrictions on physical mobility. Girls remain at a severe disadvantage when it comes to extracurricular activities, such as field visits and library or laboratory work that often extend well into the night. They are seldom allowed to take part in such activities, as their physical mobility remains under the control of their husband or male family members. Many of our respondents readily cited these cultural restrictions when asked about gender differences in performance of scientists. According to Chanana (2001), this seemingly paradoxical reality results from the intersection of macro-level development policies aimed at promoting education among women and girls with micro-level familial concerns of preserving the purity of female family members. A university marine biologist aptly summarized the contradictory nature of the manifestation of such beliefs:

> Indian women are very different from their counterparts abroad and the armory of men…If you ask a female student to be here after five in the evening, do you think that the student will be here?... You could label as cultural and you are so cautious about yourself and the society and you never let the women work according to their will or from the childhood itself she is groomed in such a way that she has restrictions around her. If you go to a foreign lab you will find a girl working up to 12 in the night and she walks off after that and she comes at 6 in the morning like men.

After marriage, a woman assumes a large amount of household responsibility, which often interferes with her education. One university scientist recalled that her social

position as a married woman had led to difficulties and missed opportunities earlier in her career:

> Since my husband was also away I had to look after both the children. I liked to attend the summer or winter courses organized by other universities, but I cannot go, as I do not have any help at home.

In this context, Derne (1994) maintains that the limitations placed by marriage on education and training are nearly inevitable. Although men in Kerala generally value higher education for women, they push their female relatives to marry by their early 20s. Such action is viewed as a preventative measure for maintaining one's reputation and respectability. Within the social context of Kerala, this ideology prevails, as women are more highly educated than any other part of India, but are ultimately expected to marry and lead traditional lives. In fact, within Malayalee culture, arranged marriages are generally preferred to "love marriages" in which the spouse is personally selected. Arranged marriages are considered highly desirable, even for the highly educated. These gender socialization practices insure that Indian women find career advancement increasingly difficult after marriage. Female respondents in this study confirmed that, as Indian women in general are not in a position to attain the degrees of productivity exhibited by male colleagues, their career trajectories will not be as smooth or far reaching. As we indicated above, owing to increasing educational attainment by women scientists, this is not due to lower levels of education but its timing and location.

DISCUSSION

Evidence from qualitative interviews with south Indian scientists on their education, travel, connectivity, and social networks leads us to propose a "circumvention" hypothesis concerning technological change. New information and communication technologies are used to circumvent the prevailing social structure of patrifocality that restricts interactional opportunities owing to concerns for female purity and control over domestic labor. The current study supports prior work (Sooryamoorthy and Shrum, 2003; Ynalvez et al. 2005) showing that Internet connectivity in Kerala has improved dramatically in the past decade. On the positive side, the diffusion of e-science technologies throughout the subcontinent now indicates a relatively high degree of Internet access for women scientists. A conservative interpretation of our results would emphasize that small changes that may have occurred in terms of professional resources and opportunities available to Indian women have not significantly changed the social and cultural codes that govern female behavior and gender relations. Our analysis does not indicate that the careers of female scientists have become less locally oriented in terms of major and routine interactional opportunities. The one area that may have seen some improvement is the frequency of short term visits abroad.

Regarding local orientation, however, our evidence yielded a different picture and some reason for optimism. The puzzle is clarified by the notion of circumvention. Women were found to possess a virtually unchanged degree of educational localism although they expressed a heightened awareness of international professional contacts and delighted in describing the international travel and professional networking in which they had engaged. Women clearly discussed foreign linkages more than their male counterparts and may be engaging in more short-term travel abroad. We cannot establish

with this analysis that women have more international professional contacts than men—but it may be equally significant if they value their international contacts more than men. As we indicated above, the social structure of interaction between Indian men and women may mean that Indian women value ties with foreign professionals more highly for two reasons: the knowledge exchanged and the style of interaction. In light of these results, it would be too pessimistic to conclude that patrifocal constraints have remained constant. While limits on mobility remain strong, the opportunities to create and maintain professional ties represented by new ICTs represent a circumvention that may herald a relaxation of constraints. Although women are not permitted to travel away from their families for long periods of time, brief, work related travel may be increasingly acceptable. While the direction of causality is impossible to establish, it seems likely to us that increases in Internet-related social capital have actually encouraged short term travel through the establishment of contacts and a greater awareness of conferences and workshops.

Despite the fact that Malayalee culture endorses educational opportunities for women, they are still expected to assume the role of dutiful wife and mother. New information and communication technologies are the primary reason for the decrease in localism. First, many of our respondents report learning about international opportunities on the Internet. Second, the probable increase in the range of women's social networks can be attributed to email communication, and an increase in international travel that also bears some relationship to Internet communication and information search. Third, there is a perceived decrease in isolation of Indian women scientists, now that they can publish in international journals and online publications, which may increase their visibility

throughout the rest of the world. When viewed in the patrifocal structural context, the relationship between female scientists in India and the Internet is nontrivial.

In light of the growing importance of non-exploitative development programs, the reduction of gender inequities in research careers is an important aspect of egalitarian science and technology development policies (Harding, 1995). Career attainment and productive research capabilities are limited for women, since many originate from religious prescriptions and limit their physical and social mobility through concerns for female purity and the demand for control over their activities (Abraham, 2000). However, educational attainment for the female scientific community of Kerala has increased over the past decade, such that the proportion of women with doctorates in our sample equals that of men. The problem goes both ways: merely increasing the number of women will never equalize the scientific playing field, without attention to structurally based factors such as the allocation of resources and access to social capital (Fox, 1995). But technological resources that provide opportunities for social capital development will have limited benefit without other changes that limit career advancement.

In conclusion, we find some reason for believing that the professional careers of Indian women are changing with the diffusion of E-science technologies. In the new context of equal educational levels, but continued limitations of mobility, women scientists have become less locally oriented through the use of new ICTs and may be beginning to develop their international professional networks, This study should be viewed as a starting point for a systematic analysis of professional and organizational networks, to determine whether changes in local orientation are accompanied by real changes in network size. Further, the relationship between age, connectivity, and locality

deserves further consideration, given the importance of younger cohorts in routinizing Internet collaboration (Shrum, 2005). In the early years of the new millennium, there is still reason to hope that circumvention can lead to broader social change.

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APPENDIX A

Thematic Organization Used in Interview Coding

- LOCATION OF HIGHER EDUCATION
    - Post Graduation
        - Institute
    - Doctoral Studies
        - institute
        - period of commencement
        - area of study
        - findings of the study
    - Post Doctoral Study
        - institute
        - period of commencement
        - area of study
        - findings of the study
    - Others
- ORGANIZATIONAL INVOLVEMENT
    - Professional
    - Non Professional
    - No Involvement
- VISITS ABROAD
    - Training/Workshops
    - Fellowship

- Guest Faculty
- Obtaining Degrees/Taking Courses
- Conferences
- Deputation
- Resource Person
- Effect/Influence
- No Professional Visits Abroad

- PROFESSIOAL CONTACTS
  - Purpose
    - professional
    - nonprofessional
  - Origin of the Contact
  - Level of Contact
  - Mode of Communication

- INTERNET USE AND ACCESS
  - Impression About Internet
  - Latest Internet Activity
  - Problems Encountered
  - Unique Internet Experiences
  - Introduction to Computers
  - Impact of Internet
    - teaching
    - social life

- research
- Use of Internet
  - research
  - teaching
  - others
- Browsing
  - duration
  - sites visited
  - ways of browsing
- Access to Internet
  - institute
    - speed
    - availability
    - future developments in internet access
  - home
    - speed
    - availability
  - cafe
    - speed
- Negative Impact of Internet

- EMAIL
  - Email Activity/Duration Rate
  - Nature of Email Response

- Correspondence Built on Email
- Rate of Mails sent and Received
- Email Transactions
    - partners
        - personal
        - professional
            - research related
            - others

- GENDER ASPECTS
    - Research
    - Occupation
    - Study

NOTES

[i] Gender differences in professional communication networks should be viewed in light of the more general finding that scientific networks in the developing world are always predominantly local (Shrum and Campion, 2000).

[ii] We have not included an account of the feminist critique of science and technology, the use of gendered metaphors in scientific discourse, or biased standards of evaluation (see Fox 1999 for a review).

[iii] The 2000 survey was conducted at the same organizations we examine in this paper and is used throughout as a point of comparison, with the clear understanding that some aspects have changed in the three intervening years.

[iv] Kerala is the only state in the Indian subcontinent where the ratio of women to men is above one (1058 females to 1000 males). Female literacy and education have achieved surprisingly high levels compared to the national average. Total literacy is 90.92%, with male literacy at 94.20% and females literacy at 87.86%.

[v] In most developing areas, the receipt of "foreign" degrees is considered superior both in terms of quality of education. Our argument concerns the social rather than the human capital implications of "outside" credentials—that is, networks rather than knowledge. In either case, the prestige of an international degree is nearly always higher, which is why we focus specifically on location as an indicator of the process.

[vi] Since the second survey was conducted in the same institutions where our qualitative interviews were conducted, differences in the level of educational qualifications can be regarded as insignificant for the analysis that follows.

[vii] It is important to emphasize that this was not independently verified, and other evidence suggests the weakening of such ties over time (Shrum, 2005).