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Gender and Science in Developing Areas*

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Gender and Science in Development

Abstract

Why do women have more difficulty pursuing research careers than men? Although this topic has been extensively investigated in industrialized countries, prior studies provide little comparative evidence from less developed areas. Based on a survey of 293 scientists in Ghana, Kenya, and the Indian state of Kerala, we examine gender differences on a variety of individual, social, and organizational dimensions. The results show small or nonexistent differences between women and men in individual characteristics, professional resources, and the organizational conditions under which research is conducted. But if gender makes little difference in these factors, why do women experience more difficulties in pursuit of a scientific career? We argue that a combination of educational and research localism increases the likelihood of restricted professional networks for women. Gender inequality in the research systems of the developing world may be based on systemic deficits in the acquisition of social rather than material resources. The most important implication is that educational policy for development should focus on international opportunities for women in the near future.

How extensive are gender differences in scientific and technical careers? A great deal of effort has been devoted both to answering this question and to examining trends over time. This interest has been driven partly by functionalist concerns with the operation of universalism and particularism in science (Cole 1979; Fox 2000; Long 1990; Reskin 1978; Zuckerman and Cole 1975). It has also been guided by a liberal feminist concern with the issue of opportunities for advancement in careers that have exhibited serious barriers to entry for women (Eisenhart and Finkel 1998; Fox 1999; McIlwee and Robinson 1992; Schiebinger 1999).[1] Functionalist and feminist scholars alike have examined science and technology as an institutional sector unique in its dual role of providing both careers for individuals and the organizational foundation for much of the knowledge on which modernity depends.

[1] Both functionalist and feminist questions are much broader than the career concerns of this essay. Issues of the selection of research problems, the nature of objectivity, the use of metaphors, the interpretation of data, and differences in approach are not addressed in the present study (see Fox 1999 for a review).

The substantial work on gender and scientific careers reveals two broad themes. First, studies of women in science through the 1980s showed an increase both in absolute terms and relative to men (Rossiter 1982; Zuckerman, Cole, and Bruer 1991). But as Fox argues, "numbers may constitute presence, but not necessarily significant participation" (1995, p. 206).[2] Research questions centered on the degree to which gender is associated with stratified outcomes such as employment location, rank, salary, research productivity, and other aspects of career attainment. Gender differences are evident in employment sector, academic rank, salary, and productivity, and often vary by discipline (Fox 1999). Differences between men and women scientists seem to be small or insignificant in location of training, financial support for graduate work, and the effects of individual characteristics (such as marriage and parenting) on productivity.[3]

A second broad theme that emerges from this literature is that women are not a homogeneous group. Studies of women in science have been conducted almost entirely in the highly industrialized countries of the North, while science in what was once called the Third World has been ignored. National research systems have replaced colonial systems in Africa,

[2] Recent initiatives to improve conditions for women in science faculties underscore the fact that discrimination continues to be a problem at major research universities (Kate Zernike, "Nine Universities Will Address Sex Inequities," New York Times 31/1/01, p.A11).

[3] The most comprehensive recent reviews are by Mary Frank Fox in the Handbook of Science and Technology Studies (1995) and the Handbook of the Sociology of Gender (1999). Until recently, much of the information on gender and science was based on relatively old information. Growth in this area is revealed by the age of references in these two reviews. In the first, more than half of the studies are from the period before 1980, while fewer than one quarter were conducted less than ten years prior to publication. In the more recent review over one third of the work was published in the 1990s. Period effects are especially important when women are entering the labor force at rapid rates, but they can be complex, owing to fluctuations in scientific labor markets, field differences in employment sector, and gender differences in career preferences (Fox and Stephan 2001).

Asia, and Latin America during the past half century. Until recently women scientists were so rare as to be nearly invisible. Thus, most samples of scientists did not offer enough variation in the gender of the respondents to assess the role of gender. In developing areas gender studies have typically focused on women as users of technology for socio-economic development (Everts 1998; Stamp 1989). What has gone largely unnoticed is that the participation of women in research careers is increasing in developing as well as developed areas (Schiebinger 1999, pp. 40-41).

This paper represents a preliminary, descriptive attempt to answer the following questions: how extensive are gender differences in the research systems of developing areas and why do women have more difficulty pursuing research careers than men? We address these issues through a survey of agricultural and environmental scientists in Ghana, Kenya, and India, administered through face-to-face interviews. Even though we sought to oversample women in order to draw a broad range of comparisons, only 25% of our respondents were women. It is important to state at the outset that this study did not focus exclusively on gender, but on the general conditions in which researchers conduct their work in LDCs. For the examination of gender, it began without strong notions of what to expect, beyond the obvious idea that women in developing countries generally experience a wide range of structural and interactional disadvantages. An attempt was made to include indicators for most of the primary gender differences that have been examined in studies of highly developed research systems.[4]

Qualitative observations helped to interpret the results below, many of which revealed small or nonexistent variation between women and men for the individual characteristics, professional resources, and organizational conditions that we suspected would display marked gender differences. Yet if gender makes little difference in these factors, this leaves hanging the question of why women experience more difficulties in pursuit of research careers, as the small number of women scientists in the three locations indicates. We argue that a combination of educational and travel limitations restricts the professional networks of women in important respects. In the following section, the methodology of the study is described. The results are organized in terms of five themes. First, we ask who these women are: do they differ from their male counterparts in terms of educational and personal background? Second, we consider their professional lives in terms of the work they do, their participation in professional activities, and research productivity. Third, we ask what kinds of organizational resources they possess. In most of these areas gender differences are not large. Fourth, we compare the professional networks of women to those of their male counterparts. Finally, we address the consequences of

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[4] Our approach was to administer a survey, but also to keep our eyes and ears open. While a survey is not an ethnography, personal interviewing in the developing world necessarily involves a great deal of observation that goes beyond the survey instrument itself.

the observed differences between women and men. We argue that gender inequality in the research systems of the developing world may be based on systemic deficits in the acquisition of social rather than material resources.

Methodology

The results below are based on a survey of professional scientists in agriculture, environment, and natural resource management. Questions focused on individual characteristics, resources, social networks, and the organizational conditions under which research is conducted. The survey was administered in Ghana, Kenya, and Kerala (a state in southwestern India), with approximately equal number of respondents in each location. Sites were selected to represent three different stages of the development of the research community in LDCs, Kerala being the most developed, and Ghana the least (Shrum and Beggs 1997).

The sample was selected in two phases. First, a bibliographic search of seventeen international data bases was used to identify the main research organizations. This method gives an incomplete picture of research activities in LDCs, particularly because it fails to identify nongovernmental organizations that do not publish results in the primary literature. The second phase involved asking informants in each location to name NGOs that were involved in research such that the most frequently named NGOs could be included in the sample.[5]

A team of three researchers, including nationals, conducted the survey in each location. The final sample consisted of 293 researchers in four sectors: 154 respondents in state research

[5] Details on the study sample and methodology are available elsewhere (Shrum and Beggs 1997).

institutes, 82 in universities, 42 in NGOs, and 15 in international research centers.[6] A standard response rate is difficult to calculate owing to the method used to obtain individual interviews and the absence of any comprehensive sampling frame for these dispersed research systems. The objective was to conduct interviews at every significant research organization in the academic, state, and NGO sectors in the three developing areas. In each organization, specific respondents were selected on site, generally with the assistance of the director, head of department, or other administrator. Typically, we sought to interview from two to four researchers, depending on the size of the organization.

[6] All international research centers were located in Nairobi, Kenya. Although the private sector conducts a limited amount of research it was not included in the sample.

In the selection of individual respondents, we used two criteria. First, we attempted to interview at least one researcher who appeared on the bibliographic list--that is, with international visibility--and one researcher who did not appear. Second, we actively sought to include women wherever possible.[7] Most directors, when asked about women scientists, did not find the topic odd. They understood why women were soliticited as respondents, because women were clearly "on the agenda." Some showed pride at having several female staff members. Even many that did not employ any women offerred that hiring qualified women would be a positive step.

[Table 1 about here.]

About one quarter of all respondents were women. Owing to the selection process, it should be borne in mind that the gender composition of our sample overestimates the number of women in the research sector in these developing areas. As Table 1 indicates, they constitute 37% of Kerala respondents, 25% of Kenyan respondents, 15% of Ghanaian respondents, and 27% of respondents in international centers. The unequal proportions in each location reflect the relative number of women scientists in these research systems. The smaller proportion of Ghanaian women results from the fact that more institutions have no women on their staff. The greater proportion of female researchers in Kerala was not unexpected and is one indicator that this location is the most developed of the three areas. Kerala is known for its high rate of female literacy and women have achieved greater progress than in many other Indian states (Franke and Chasin 1994; Heller 1996; Iyer and MacPherson 2000; Jeffrey 1992; Parayil 1996;

[7] A bibliographic search alone is not adequate to identify women because (1) names are not always gender specific, and (2) initials rather than full names are often used in bibliographic databases.

Sooryamoorthy 1997).

[Table 2 about here]

The sectoral distribution of men and women in Table 2 does not reveal large differences. Women represent between 20% and 30% of our respondents in national research centers, universities, and NGOs. We found the highest proportion of women in national research centers (29%), and the smallest in universities (21%).[8]

[8] This result contrasts with the US case in which women are most strongly represented in the academic sector (Fox 1999: 446-7). However, in the US the main employment alternative is private industry, which is not the case in developing areas.

The findings below derive from responses to a survey instrument composed of closed- and open-ended questions. In what follows we examine gender differences in organizational position, productivity, and professional activities.[9] First, we ask who these women are in personal terms. Second, we consider their professional lives--the work they do, their participation in professional activities, and productivity levels. Third, we ask what kinds of resources they possess. Fourth, we compare their professional networks to those of their male counterparts. Fifth, we examine consequences of the observed differences between women and men. In the discussion that follows, we argue that gender differences in these research systems are rooted in systemic inequities in social rather than material resources. The primary process is that educational and research localism increases the likelihood of restricted professional networks for women.

[9] Our procedure for the analysis is as follows. For ordinal and ratio variables, we used t-tests for mean differences by gender. We tested the assumption that each variable had the same variance for male and female respondents. When we were unable to reject the hypothesis of equal variances, we ran the t-test. Otherwise, we ran the Cochran test. To examine ordinal level variables we used the Kruskal-Wallis test. In the case of a dichotomous independent variable such as gender this is equivalent to the t-test (Hatcher and Stepanski 1994). For nominal level variables we employed a Chi-square test, or Fisher=s exact test (when over 20% of the categories showed an expected frequency of fewer than five).

Results

Approximately five dozen questionnaire items were employed to indicate respondent priorities for the development of the research system as well as their attitudes towards agriculture, the environment, the state, nongovernmental organizations, and global issues. On the vast majority of these questions gender differences are negligible. On items that relate to organizational context, women do not report any overt differential treatment. For instance, they feel equally free to choose their research topics and publish their results. Yet the two questions directly addressing gender elicited highly significant differences.[10] Women were much more likely to agree that "The research system would be better if there were more women researchers." They were much more likely to disagree that "It is just as easy for women to get ahead in a research career as for men." Such a result is to be expected. Indeed, it would be more surprising if the difference did not appear. But it is at the heart of of our analysis: Why do women feel it is harder to get ahead than men? The answer, we suggest, lies ultimately in educational and work processes that result in restricted professional networks.

Background

Table 3 exhibits demographic characteristics and educational achievements. The results indicate an average age for both men and women scientists in the early forties. The vast majority (97%) are citizens of Kenya, Ghana, and India. With respect to the composition of the research system, the process of decolonization in these countries is virtually complete . Foreign

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[10] Most of these items are not relevant to the present analysis and are not presented here. One other group of three items reveals a significant gender difference and is considered in the discussion.

scientists, apart from visitors and temporary appointments, are quite rare.[11]

[Table 3 about here]

The majority of respondents are married, but with important differences along gender lines. Almost all men (95%) are married, as compared with three-quarters of the women. Women have significantly fewer children, reporting closer to two per family as against nearly three per family for men. Indeed, 16% of these women are pursuing a professional career without children at home--about twice that of men. Raising children is not just a consequence of being married, since five of fourteen single women and only one of seven single men, have children. Given the similar age structure of the sample for men and women, this suggests that men and women do not handle their family and professional lives in similar fashion. The lower proportion of married women and their smaller number of children indicate that women who do enter scientific careers are more likely to postpone or avoid family responsibilities than men.

The occupational background of the respondent's father and spouse also varies significantly by gender. In the case of the father's occupation, the distribution across categories is more balanced for women than men. This results from the fact that forty-two percent of men

[11] In terms of religion and race, the significantly higher percentages of Hindu and Asian women, compared to Muslims, Christians, and Africans is simply due to the fact that about half of the women interviewed were from Kerala.

(almost twice that of women) come from a farming family. Since the largest group in this sample consists of researchers involved in various agricultural topics, it follows that men are much more likely than women to have some direct experience with the field of application of their work. Compared with men, a greater proportion of women had a father who worked in the public sector--a teacher or a civil servant. Very few respondents of either gender come from a science background (professor, researcher, or scientist), a finding that reflects the relatively recent development of the research sector in developing areas. The distribution of spousal occupations also differs by gender. Wives of male researchers tend to have a lower position on the occupational scale in terms of income, authority, and prestige (one quarter had a spouse who did not work outside the home). By comparison, women are four times as likely as men to have a spouse who was a researcher or scientist.

Education

Table 3 shows that the majority of all researchers have some postgraduate training.[12] Though men and women do not differ significantly in this respect, men are more likely to have a doctorate. However, a larger difference is evident in the location of higher education. Men are more likely to be trained in developed countries (principally the US and Europe) and, on average, spend more time abroad for training and education. Over half the male researchers in the sample were educated in DCs, compared to about one third of the women.

We examined the relationship between gender and training abroad by country (table not

[12] This seems obvious in the developed world, but until recently it was not unusual to hire an agricultural researcher with only a first degree, with the hope that funds for graduate training could be provided.

shown). The gender difference is not apparent across all locations, but only for Kenyan respondents, where 58% of female respondents but 81% of men went abroad for education. By contrast, Indians are quite unlikely to go abroad for training (only 5% of Keralan women and 8% of men were educated outside of India). Since the system of higher education in India is more extensive, African students are more likely to be trained abroad than their Indian counterparts. Multilateral and bilateral donor support for education in developed countries is much greater for Africans than Indians. Still, national context influences the extent to which men receive preferential access.

Table 3 also shows that men spent 2.63 years in developed countries, while women spent an average of 2.06 years.[13] Men are more likely to travel abroad for education and visit developed countries than women. Nearly half the women in the sample (47%) had no experience in developed countries, as contrasted with one quarter of the men. Male scientists have more exposure to international institutions and practices through travel than their female counterparts. This is not so evident in the duration of the experience, but in the proportion who have it.

In the following section, we examine whether these differences in personal background, and particularly in education, also exist in the work context.

Professional Status

Professional activities of scientists include the volume of research they do, their collaboration with colleagues, their participation in professional organizations, and their

[13] Removing the outlier who spent 31 years in developed countries, the female average drops to 1.66 years ($p<.05$).

productivity. As indicated in Table 4, women and men share comparable work loads, work descriptions, and productivity patterns. On average, the scientists surveyed had been employed for about ten years in their current organization. This tenure does not in itself indicate opportunities for mobility, which are in general quite low. Rows 2 and 3 of Table 4 show that men and women do not differ significantly in the volume of research projects they participate in or direct.

[Table 4 about here]

Men and women scientists report spending comparable time at work and on research in a given week, though the former reported slightly longer work weeks, and more hours of research. What proves more revealing is the structure of their work time as indicated by a measure of travel. Men are away from their organization significantly more than women, by a difference of two weeks per year (row 6). Unlike the international travel differences above, this results not so much from how many researchers travel (only 4% of male respondents and 11% of the female respondents did not travel at all) but from differences in the duration of travel.

Table 4 also reveals that men and women exhibit more similarities than differences in their professional activities. Almost all participate in workshops, and the vast majority participate in review meetings, training courses, farmer functions, and meetings with extension workers. Men and women attend comparable numbers of professional meetings, with an average of 9 meetings for male respondents, and 8 for women. However, in the activity that best indicates status, men and women differ markedly. Almost one third of male scientists report service on the editorial board of at least one journal, a position held by only 14% of women (row 8).

Although most of these differences are small and not statistically significant, gender may be related to membership in various types of professional groups (rows 14-20). Most respondents were members of professional associations at the time of the interview, but showed uneven participation in other groups. Men were more likely to report membership in professional associations and environmental groups. They were more likely to hold office in professional organizations, serve as consultants, on government committees, and as advisors to NGOs.[14]

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[14] The question remains as to whether this participation (in professional groups) was voluntary (solicited by the recipient organizations) or required by the respondent's organization.

Men and women do not differ greatly in their number of coworkers. On average, women scientists report working closely with 21 individuals, slightly more than men. Both groups interact mostly with other scientists, technicians, and field workers. Women, however, work closely with significantly more scientists than they supervise. On average, they work closely with nearly twice as many scientists as men. This may be a measure of women's lower status in the organization but it could also mean they are more likely to prefer collaboration.[15]

[15] Evidence on gender differences in collaborative tendencies is mixed (Fox 1995; Xie and Schauman 1998). Most of these studies measure collaboration by the number of co-authorships, while our measures are based on the number of individuals in various categories with whom the respondent works closely.

The production of written material and presentations is the most visible and tangible part of the research process and the source of organizational and reputational rewards. Publication counts are the most common general measure of productivity. In the production of scientific work a minority of researchers account for most publications, a finding consistent with productivity studies in developed countries (Long and Fox 1995).[16] More than two thirds of the women and about half of the men did not report publishing anything in foreign journals. Most studies in the developed world have shown higher overall rates of productivity for men (Fox 1999: 450). Table 4 shows that men and women display similar levels of self-reported productivity for most indicators (rows 33-40). However, one difference is both statistically significant and substantively important. Men reported higher productivity in the international scientific arena (row 36), reporting an average of 2.29 articles in foreign journals over the time period, while women reported only 1.34 ($p<.10$). When we exclude international institutes and NGOs, the difference becomes even larger (2.33/1.15, $p=.04$). Men may be more highly motivated or more successful at publication in foreign journals as a result of their greater educational and travel experiences in foreign countries.

In sum, with respect to most features of professional activity, women scientists do not differ much from their male counterparts. The notable differences are that (1) women spend less time away from their organization than men, (2) they are less often members of government committees, advisors to NGOs, and editorial board members, and (3) they publish fewer articles in international journals. For all other indicators of productivity, membership, meeting

[16] **Studies of gender differences in research productivity in developed countries generally report higher productivity for men (Fox 1995; Xie and Schauman 1998)**.

attendance, or workload, gender does not have a significant impact.

Organizational Resources

In resource-poor areas research institutions frequently lack the equipment needed to carry out basic professional tasks. Scarcity is not absence, however. Are there gender differences in the distribution of organizational resources? While we were not able to obtain reliable information about salaries, Table 5 allows us to examine gender differences in terms of position and other factors. Men and women supervise comparable numbers of staff, mostly technicians and field workers. The only difference in organizational position is in the supervision of postdoctoral students, where women supervise significantly fewer (1.33 postdoctoral students for men as compared with .53 for women). When we control for organizational sector, the gender difference is only significant in the university setting.[17]

[Table 5 about here]

[17] **For other staff categories, the inclusion of the sector variable did not affect the results.**

Men and women reported similar access to other types of professional resources. Most respondents had at least some access to a typewriter, a computer, a printer, and a secretary (rows 7 through 14). Fewer than half had access to a fax machine. Mainframe computer and email access was available to only one tenth of these scientists. Although email has become commonplace as a means of communication in industrialized countries, its presence is still scarce in LDCs. The one resource difference reported in this set of factors was access to a telephone, which favored women (81%) over men (69%).[18] Even local calls, however, are expensive in the study locations, so access to a phone should not be equated with use.

A separate set of questions was answered by the interviewers themselves immediately after the session was complete (rows 15 through 19). These answers were based on observation in the office where the interview was conducted. Note that the presence of communication devices witnessed by the interviewers is slightly different from the respondent's own account. The former yields lower estimates of availability, suggesting that many resources are shared, as in cases where several professionals make use of a phone, typewriter, or computer. Table 5 indicates a statistically significant difference between men and women in interviewer-observed personal computers, suggesting that women are more likely to share.

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[18] This difference could be more important with the introduction of widespread Internet connectivity based on dialup connections. However, a smaller survey conducted in each of these locations in early 2000 did not reveal any significant improvement in this area.

Professional Relationships

If gender makes little difference in professional activities and organizational resources, we are left with our intial question. Why do women have more difficulty pursuing research careers? The proximate origin of this difficulty lies in the educational findings above. First, women are subject to "educational localism." That is, men are more likely than women scientists to possess the doctorate, to have at least some training in developed countries and to spend more time abroad for training and education. The consequences are increased exposure to nonlocal institutions and higher proficiency in English, the international language of science. Second, women are subject to "research localism." As we have seen, work time is structured differently for men, who travel more than women. What difference do these factors make? The combination of educational and research localism increases the likelihood of restricted professional networks for women.

We assessed professional relationships in two ways. First, respondents were asked to enumerate all contacts with an eight page list of national and international organizations, distinguishing the type of contact (e.g., employment, friendship, funding, workshops). The total number of reported relations with other organizations does not vary by gender. Men report an average of 24.07 relations, and women an average of 24.84. We next examined the average number of each of the nine types of tie, but again there were no differences by gender (results not shown). With respect to the relatively "weak" ties indicated by the wide range of organizational linkages, differences between men and women are trivial.

[Table 6 about here]

The second method utlized individual-level ties between professionals. Respondents were asked to name those outside their organization whom they considered the most important professional contacts for their work. Table 6 shows that unlike the weak ties of organzational linkage, the average number of professional contacts differs by gender. Men mentioned an average of 4.86 names while women mentioned only 4.26, a difference that is statistically significant at the .10 level. Men and women do not differ greatly in terms of the formal, often impersonal relations they have with other organizations, but they do when it comes to informal ties to other professionals.

Where are these professional relationships located? Sector and location were coded from the organizational affiliation. Table 6 presents the average number of contacts within and outside the local research system. Most professional contacts are with individuals in the area where they work and live. In what is still a non-Internet environment, the majority of social ties are based on proximity, where barriers of communication and transportation are lower and scientists can interact in person. Row 3 shows that gender does not influence the number of local contacts significantly. In fact, the direction of the difference favors women over men. Averages for each location show that in Kerala, the location with the largest number of women scientists, men reported significantly fewer local contacts than women. In Ghana and Kenya, no difference is evident.

The primary gender difference emerges, however, in the average number of contacts outside the local research system (row 4). Men have significantly more relationships than women with foreign professionals. That is, the gender difference lies primarily in linkages to developed countries rather than those in other developing areas. Men named an average of 2.48 contacts outside their location, including 1.09 in developed countries, while women named an average 1.90 outside contacts, with only 0.71 in developed countries--both differences significant at the .05 level.[19]

[19] This finding is reinforced by answers to a Likert-type item in which men were significantly more likely than women to report frequent professional discussions with people outside the country ($p<.01$). While such items are not as accurate as a count of reported contacts with specific individuals, this tends to confirm the finding that men are more likely to have distant professional ties.

Since gender affects the geographical distribution of professional contacts, we sought to learn whether there were differences in organizational context. Rows 13 through 28 of Table 6 present the sectoral distribution of local and foreign contacts.[20] There are two notable effects, pertaining to local and international contacts. First, at the local level, women have significantly fewer contacts with nongovernmental organizations. Recalling that women are less often involved in these organizations as advisors (row 19 of Table 4), it makes sense that they have fewer contacts with NGOs. Second, for most categories of foreign professional ties, men report more contacts than women, but the difference is statistically significant only for foreign universities and businesses. Contacts with universities account for most international relationships for both men and women. Women are relatively disadvantaged in having significantly fewer contacts with universities in developed countries.

Finally, we wondered whether this deficit should be described as a difference in international connectivity or a difference in nonlocal connectivity. The difference is important for large countries such as China, India, and Brazil, where the national research systems are relatively large. This issue can be addressed by asking whether the effect of gender on foreign ties is constant across the three locations. Indeed, the situation is different for Kerala, a relatively small state within India. Kerala respondents have significantly fewer contacts with foreign universities than respondents in other locations. Since nearly half the female respondents

[20] For Kerala researchers, the "local' category refers specifically to contacts in Kerala rather than India as a whole.

in the survey are from Kerala, women report fewer international contacts. Therefore, this reflects a difference in the local context of research, rather than a gender difference.

Why should it be the case that researchers in Kerala, scientifically the most advanced of the three areas, have fewer foreign contacts? For these scientists a distinction may be drawn between contacts outside India and other nonlocal ties, specifically contacts outside Kerala but within India. Owing to the size of the Indian subcontinent, the latter operates as the main educational and scientific context for Kerala researchers. These respondents have fewer foreign contacts than respondents in other locations because other Indian states, rather than the international community, constitute the primary location of external ties, including those ties first developed during postgraduate training (Shrum and Campion 2000). When other Indian states--that is, the community of scientists outside Kerala--are viewed as the external environment, the average number of contacts with Indian universities, ministries, and NGOs, does vary significantly by gender, as indicated in rows 24 through 28 of Table 6.[21] Most important, men have more ties to other Indian universities outside Kerala than women. Since Kerala women have significantly more contacts in local universities than their male counterparts,[22] these results suggest a tradeoff between relationships with the local and nonlocal environment. Networks of male scientists tend to "reach" farther than women's networks. The professional networks of male scientists are more external, more cosmopolitan, while those of women suggest a more local orientation.

[21] An analysis by sector did not modify this result.

[22] A significant interaction is present between gender and location: Kerala women have significantly more contacts with local universities than their male colleagues.

Consequences of Localism

Are there any specific effects produced by a more local orientation? As we have seen, there are few overt differences in access to certain kinds of resources and organizational status. Yet similarities on these dimensions may be accompanied by more subtle linguistic or attitudinal differences. In this final section we consider three.

[Table 7 about here]

(1) Of all communication tools, language is the most basic. English-language ability may be the most significant skill required to appropriate international scientific resources. In our sample of scientists, competence in English was not evenly distributed.[23] Since men and women differ in international exposure and productivity, perhaps men possess a linguistic advantage. Indeed, the interviews were conducted in English, which is not typically the first language in either Africa or India. Male and female scientists did exhibit significant differences in their ability to express themselves and understand English. The interviewers noted that 13% of women, but only 4% of men, had trouble hearing, understanding, or both. Eleven percent of female respondents were also difficult for the interviewer to understand, as against 4% of men. This may be a consequence of the reduced access to foreign education for women. Male and female scientists do not appear to have unequal access to personnel or material resources, but

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[23] The seven interviewers assessed spoken rather than written English.

women are at a disadvantage in their ability to use English in their professional careers.

(2) We were not able to measure access to international resources directly. However, we sought an indirect indicator through a measure of awareness. We asked respondents whether they were familiar with new funding opportunities since the Earth Summit held in Rio de Janeiro in 1992. While only a minority of respondents were aware of such opportunities, nearly twice as many men (slightly over one fifth) reported such awareness. This difference, too, may be understood with reference to linguistic and social deficits. Gender differences in communication skills and network structure have tangible consequences. If women do not have access to the same level of information as men, particularly in an area as critical as funding opportunities, they are at a disadvantage with respect to career resources.

(3) In the 1990s the most salient issue facing the research systems of LDCs was the increasing international emphasis on environmental issues. Global concern with sustainability created new pressures on national research systems in developing areas even as development funds were declining. Since the sample of researchers here was broadly selected to include those concerned with agricultural, environmental, and natural resource issues, they were acutely aware that the dynamics of the international aid focus were shifting. Local orientations are not necessarily narrow. A focus on local problems may well be a better use of national scientific resources than contributions to the international scientific literature.

Attitudes toward environmental issues are particularly important, given that these are the individuals developing local knowledge in the agricultural and environmental fields. Men and women are equally aware of sustainability issues. Gender does not affect commitment to environmental problems, as shown by the non significant difference on an index of attitudes towards the environment.[24] But are they equally oriented to local conditions? *Environmentalism* reflects a concern for the protection of the natural environment regardless of economic considerations, as expressed by the environmental movement in developed countries (Adeola 1998). *Tiers-mondisme*[25], on the contrary, represents the tendency to view environmental issues from a regional or local, as opposed to an industrialized perspective.

Table 7 shows that women are more *tiers-mondiste* than men in general ($p<.10$). However, there is a significant interaction of location and gender. In Ghana, women are significantly less *tiers-mondiste* than men, while in Kerala, they are significantly more *tiers-mondiste*. In Kerala, where women have relatively greater representation in the research system and have more local contacts than men, they are more likely to see environmental issues--at least as defined by the developed countries--as subordinate to the needs and interests of their region.

Discussion

[24] Respondents were presented with a list of statements on environmental problems, and asked if they agreed on a four-grade Likert scale. Responses were used in a factorial analysis to examine the underlying dimensions of attitudes to environmental conservation. Factors were extracted with the principal factor method, followed by a promax (oblique) rotation. A factor was kept if at least three items loaded on it with a loading greater than 35. Two factors met the criteria and were kept for the final analysis. (1) *Environmentalism* combines the three following statements: "Water pollution is a big problem in Kenya/Kerala/ Ghana," "Industrial pollution is a big problem in Kenya/Kerala/Ghana," and "Agricultural research should concentrate more on increasing productivity in favorable than in marginal regions." (2) *Tiers-mondisme* combines the following items: "Environmental problems in the Third World have been exaggerated by industrial countries and donor agencies," "Environmental issues are a rich-country obsession that Kenya/Kerala/Ghana cannot afford," and "The research system in Kenya/Kerala/Ghana has considered the environmental costs of production for many years."

[25] The French term *tiers-mondisme* can be translated in English as "Third-worldism". It refers to the critique of industrialized countries by LDCs (Rist 1997). The concept and measure are described more fully in Campion and Shrum 2002.

Based on these results an initial account can be given of the ways in which gender affects the organization of scientific careers in developing areas. The process through which gender differences emerge and develop has unintended but systemic consequences that require policy deliberation and action.

The comparison of men and women scientists in terms of access to resources, organizational status, and professional activities reveals more similarities than differences. Where there are differences, they are not always in a consistent direction. Men and women participate about equally in workshops, review meetings, training courses, and activities with farmers and extension workers. They participate about equally in professional meetings generally. There are insignificant differences in supervisory roles. Although our study did not include specific varieties of laboratory and technical equipment, men and women report similar levels of access to material resources.[26] [27]

Nonetheless, women researchers in Ghana, Kenya, and Kerala view themselves as having greater difficulties than men. The women in our sample were less likely than men to have obtained a doctorate, less likely to have travelled or trained in industrialized countries, and less often travel outside their organization. We argue that these differences are associated with traditional familial roles in a specific way. The statuses of 'wife' and 'mother'--which are

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[26] Two qualifiers are important to note in this discussion of similarities. Since our interviewers targeted active researchers, it does not reflect the fact that women are underrepresented at the higher levels of management and organization. Too, equal access to resources is sometimes a function of generally low access. In a research institute where an Internet connection is not available, all have equal access.

[27] **There are two exceptions. Women are more likely to report ready access to telephones, but less likely to have exclusive access to a personal computer.**

particularly strong in developing areas--are generally viewed in terms of the prescribed activities and role relationships associated with their fulfillment. The results here suggest future research should focus on associated opportunity costs in areas such as education and travel.

We propose that the mechanism is twofold. First, traditional role occupancy involves caretaking responsibilities that make travel for extended periods difficult. This is clearest in opportunities for advanced training, especially where they involve study abroad or outside the state.[28] However, in discussions with respondents, it often seemed to apply to work-related travel within these arenas as well. Such opportunities are in practice, if not in principle, heavily weighted towards men, who are viewed as less constrained by family ties, or even obligated to travel owing to their role as provider. Of course, whether a particular individual has these responsibilities is more significant than whether women as a category have them when decisions are made about education abroad or travel. But as in developed areas,[29] women scientists in

[28] The second author conducted an evaluation of a US-funded graduate training program in Kenya. Women were almost never included in the program. The most common (unsolicited) critique was that families were not funded to accompany the participants. Women were effectively excluded by this provision.

[29] Studies have shown that female scientists are less likely to be married or have children than male scientists (Long and Fox 1995, p. 56).

Africa and India organize their professional careers differently than men, a difference that is most evident in the postponement of family ties resulting from marriage and childbearing. If this is true, then why should there be a general educational and travel deficit for women? A cultural disposition that ties women more closely to their residence for familial and security reasons may be the answer.[30]

The comparison of men and women with respect to social capital reveals other differences. Our findings show that women are not disadvantaged in terms of their weak ties to a broad variety of organizations. Our most comprehensive indicator of linkages with a large group of national and international organizations in academic, governmental, and nongovernmental sectors showed that gender is not related to the number or type of social relationships. However, women do report fewer informal ties to other professionals they see as important to their work. This difference lies primarily in contacts with developed countries, where women report fewer ties, rather than in contacts with developing areas, where they sometimes report more. Contacts with the academic sector account for most international contacts. Women, who are less likely than men to train or travel outside the local area, have fewer opportunities to develop

[30] There are in all likelihood regional differences here. Anecdotal accounts of Chinese emigration indicate that Chinese women are less likely to travel to the U.S. for graduate work than men, but more likely to remain once here.

relationships, and fewer professional ties to these external institutions. In Kerala, where the salient environment for science consists of surrounding Indian states, respondents have fewer foreign contacts. But the pattern is repeated in the Indian context. Men have more ties to Indian universities outside the state than women, but Kerala women have significantly more contacts in local universities than their male counterparts. While the professional networks of male scientists tend to be more externally oriented, reaching farther than women's into the scientific environment, networks of women suggest a local orientation.

According to one important strand of the social networks literature, networks may be viewed as allocating and providing social resources (Hurlbert, Haines, and Beggs 2000). The networks examined above are constructed by individual men and women during the course of educational and professional employment. Their development does not occur independently, but emerges in the context of the hierarchically-structured organizations that educate and employ scientists in developing areas. As scholars have noted in the Western context, gender inequities may be more likely to develop at the departmental or organizational level than within a research specialty (Cole 1979; Fox 1995). Using bibliometric and ethnographic data from departments in two Swedish universites, Mählck shows that gender biases are often located in perceivedly gender-neutral processes and practices in the everyday working lives of researchers (2001: 167-8, 186-8).

We argue that seemingly simple organizational decisions to sponsor or encourage individuals to seek advanced training or travel for work-related purposes have important consequences for the kinds of ties that will be developed and the kinds of resources that are accessible. In contrast to the developed world, where most individuals finish an advanced degree before seeking permanent employment, many individuals in Africa, Asia, and Latin America are already employed in research, teaching, or assistantship positions before postgraduate training occurs. As Smith-Lovin and McPherson argue in their network approach to gender, the "core insight of the network perspective is that small differences in access to information will accumulate over the course of a career" (1993, p. 230). If the professional networks of male scientists become more externally oriented through education and professional travel, their information sources, as well as their orientation to research may become more international and less local than those of women.

The findings above also allow us to speculate on some of the potential consequences of international and local orientations to the research career. The first is that some women scientists may be at a disadvantage in their ability to use English in their professional lives. English deficits may be a cause of difficulty in establishing international scientific contacts, but they are also a consequence. If women are not selected for training and workshops outside their organization, they are less likely to form professional relationships with scientists and potential collaborators outside the local area. Linguistic difficulties may render them less confident in their ability to establish ties with foreign scientists, ties that might lead them into new areas of research or awareness of opportunities.

Women were less likely than men (1) to report knowledge of new funding sources, (2) to publish in foreign journals, and (3) to adopt First World views of environmental issues. Each of these is consistent with the notion of limitations imposed by restricted professional networks. Contacts with scientists outside the local arena are more likely to generate knowledge of new, especially multilateral, bilateral, or nongovernmental funding sources. In terms of the documents that communicate the results of scientific research--the dimension that has been the focus of most traditional sociology of science--men and women display generally similar levels of productivity except in the international scientific arena.[31] Moreover, women scientists in Kerala were more likely to exhibit *tiers-mondisme*. That is, they are more likely to hold the view that environmental and sustainability issues are problems of the North rather than the developing world. Such a view is consistent with a local orientation to research problems.

The recent development of technical and research careers for women in the South raises an important issue: Are institutional considerations of gender equity incorporated into organizations that are themselves adapted from Northern forms? We have shown that in many respects, differences between men and women researchers are smaller than one might expect, even in areas where traditional gender roles are still dominant. Is it correct to add developing areas to Evelyn Fox Keller's assessment that "the primacy of gender has receded as an occupational barrier in the sciences, and its utility as a critical wedge has been blunted by occupational success" (1995, p. 85)? Our results suggest that would be premature for two reasons. First, the proportion of women in our study is a result of oversampling women scientists in developing areas and not a accurate reflection of their actual presence in the research

[31] Men are also much more likely to serve on journal editorial boards and government committees.

system. Second, processes that shape networking for women and men have consequences for the development of social resources and orientations that influence research. As scientific networks become more global in nature (Schott 1993), these differences may restrict the scientific careers of women, even as their numbers within the research systems of developing areas are increasing.

What has the potential to shift this localism is the emergence of the Internet as a means of communication (De Roy 1997). If new information and communications technologies become widespread in the research systems of developing areas, the reduction in the time and effort involved in the maintenance of scientific contacts and improvement in the technological basis of research collaboration might also reduce the gender differences observed in this study. However, there is also good reason to be skeptical of such developments (Engelhard 1999a, 1999b). Relationships that have an electronic origin are more likely to be "weak ties"--where, as we have seen, women are not significantly disadvantaged--than the strong professional ties that have their origin in personal contact. Mary Frank Fox has argued that the "idea of education, by itself, as emblematic of progress for women in science is questionable" (1999: p.453). We second this view in the context of developing areas. The single most important implication is that educational policy for scientists in developing countries should focus on <u>international</u> opportunities for women in the near future.

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Table 1: Distribution of Respondents by Country and Gender [a]

Country	Male	Female	Total
Ghana	83 (85%)	15 (15 %)	98
Kenya	59 (75%)	20 (25%)	79

Kerala	64 (63 %)	37 (37%)	101
International Research Centers	11 (74%)	4 (27%)	15
Total	217 (74%)	76 (26%)	293

[a] Total percentages may not equal 100, due to rounding error.

Table 2: Distribution of Respondents by Sector and Gender [a]

Sector	Male	Female	Total
National Research Institutes	109 (71%)	45 (29%)	154
Universities	65 (79%)	17 (21%)	82
NGOs	32 (76%)	10 (24%)	42
International Research Centers	11 (74%)	4 (27%)	15
Total	217 (74%)	76 (26%)	293

[a] Total percentages may not equal 100, due to rounding error.

Table 3: Background of LDC Researchers by Gender

Variable [a]	Male	Female	N
1. Age	42.24	40.71	293
2. % Citizen of Country where They Work	96.31	97.37	293
3. % Hindu *	30.34	50.00	197
4. % Asian **	28.57	47.30	291
5. % African **	70.05	51.35	291
6. % Who Are Married ***	94.93	76.32	293
7. Number of Children ***	2.86	2.13	290
Father's Occupation * [b]			
8. Farmer/Peasant	42.25	22.54	284
9. Teacher/Education	10.33	18.31	
10. Civil Servant	9.86	18.31	
11. Nurse/Medical	2.82	2.82	
12. Researcher/Professor/Scientist	1.88	1.41	
13. Extension Officer	0.47	0	
14. Business/Merchant/Shopkeeper	10.33	7.04	
15. Other Sector	22.07	29.58	
Spouse's Occupation *** [c]			
16. Farmer/Peasant	1.95	1.72	263
17. Teacher	20.49	3.45	
18. Civil Servant	5.85	10.34	
19. Nurse/Medical	8.78	6.90	
20. Researcher/Professor/Scientist	8.29	36.21	
21. Extension Officer	0	1.72	
22. Business/Merchant/Shopkeeper	8.29	6.90	
23. Does Not Work	23.90	1.72	
24. Other Sector	22.44	31.03	
Education			
25. % Who Have a PhD	56.22	44.74	293
26. % Who Have a Master=s Degree	31.80	44.74	
27. % Who Were Educated in DCs **	52.53	35.53	
28. Number of Years Spent Outside of Location for Education *** [d]	2.65	1.76	
29. Number of Years Spent in DCs	2.63	2.06	288

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

[a] For the variable names starting with A%@, we give the results of a chi-square, and for all the other variables, the result of a t test, unless otherwise indicated.

[b] Percent of male and female respondents whose father was in each category; tested with a chi-square.

[c] Percent of male and female respondents whose spouse was in each category; tested with a chi-square.

[d] The Keralan respondents were asked if they had spent any time outside India.

Table 4: Respondents= Professional Activity, by Gender

Variable	Male	Female	N
Work Context			
1. Number of Years Working in the Organization [a]	10.79	11.36	292
2. Number of Research Projects Respondent Works on [a]	3.41	3.57	277
3. Number of Research Projects Respondent Directs [a]	2.33	2.09	276
4. Number of Hours Spent Working in a Typical Week [a]	51.39	49.38	276
5. Number of Hours Spent on Research in a Typical Week [a]	29.91	26.62	274
6. Number of Days Spent away from the Organization in the Past Year * [a]	49.95	35.61	269
7. Total Number of Professional Meetings Attended Since 1990 [a]	9.25	7.97	273
Percentage of Respondents Who Engaged in the Following Professional Activities since 1990 [b]			
8. Served on Editorial Board of Journal ***	30.05	13.70	276
9. Participated in Workshop	97.54	95.95	277
10. Participated in Program or Project Review Meeting	87.19	87.84	277
11. Went to Training Course	72.77	71.62	276
12. Went to Farmers= Fair or Field Day	84.08	81.08	275
13. Went to Meetings with Extension Workers	78.11	79.73	275
Percentage of Respondents Members of Professional Groups since 1990 [b]			
Professional Association	87.62	82.43	276
14. Held Office in a Professional Organization	42.57	39.19	276
15. Advisor to Extension Service	53.20	59.46	277
16. Member of Government Committee ***	44.83	26.03	276
17. Served as Consultant	66.50	56.76	276
18. Advisor to an NGO *	37.44	24.66	276
19. Member of Any Other Group Concerned with the Environment	39.30	30.00	271
Number of Colleagues the Respondent Works Closely with [a]			
20. Professional Scientists	6.47	8.52	278
21. Technicians and Field Workers	5.56	5.34	277
22. Postgraduate Students	2.00	1.89	278
23. Other Students	1.70	3.34	269
24. Non-Technical Staff	2.40	3.54	276
25. Others	1.02	0.67	254
Number of Colleagues the Respondent Works Closely with, but Does Not Supervise [a c]			
26. Professional Scientists **	3.74	6.26	276
27. Technicians and Field Workers	0.19	-0.92	276
28. Postgraduate Students	0.66	1.36	276
29. Other Students	-0.79	-0.61	266
30. Non-Technical Staff *	-1.50	1.06	273
31. Others	-1.33	-0.78	245

Table 4 (Continued)

Variable	Male	Female	N
Productivity (Average Number for each Item)			
32. Papers at National Workshops [a]	4.02	3.18	276
33. Reports [a]	4.47	4.99	272
34. Bulletins for Extension [a]	0.99	0.96	273
35. Articles in Foreign Journals * [a]	2.29	1.34	275
36. Articles in National Journals [a]	2.44	1.87	272
37. Chapters in Books [a]	0.48	0.37	274
38. Reviews [a]	0.86	0.30	274
39. % Who Have Received a Professional Award [b]	12.94	12.33	274

* p<.10; ** p<.05; *** p<.01.
[a] T test
[b] Chi-square
[c] A negative score means that the respondent supervises more people than s/he works with.

Table 5: Respondents= Access to Resources, by Gender

Variable	Male	Female	N
Number of Workers the Respondent Supervised [a]			
1. Professional Scientists and Engineers	2.72	2.28	278
2. Technicians and Field Workers	5.33	6.33	279
3. Postgraduate Students ***	1.33	0.53	278
4. Other Students	2.46	3.88	270
5. Non-technical Staff	4.10	2.49	277
6. Other Staff	2.28	1.46	251
Percent Who Reported Access to Communication Resources [b]			
7. Telephone *	69.05	80.82	283
8. Typewriter	64.59	72.60	282
9. Personal Computer	62.86	58.90	283
10. Mainframe Computer	11.65	12.33	279
11. Printer	65.88	64.38	284
12. Fax Machine	40.00	45.07	281
13. Email	9.05	8.22	283
14. Secretarial Assistance	76.78	71.23	284
15. Number of Journals Received Personally	1.61	1.66	272
Percent for Whom the Device Was in the Room at the Time of Interview [b]			
16. Telephone	55.56	49.32	280
17. Typewriter	15.46	13.89	279
18. Personal Computer *	23.41	13.70	278
19. Fax Machine	7.32	5.48	278
20. Printer	18.45	10.96	279

* p<.10; ** p<.05; *** p<.01.
[a] T test on the average number reported
[b] Chi-square

Table 6: Respondents= Professional Relationships, by Gender (T test)

Variable	Male	Female	N
Professional Contacts			
1. Number of Relations with Other Organizations	24.07	24.84	289
2. Number of Professional Contacts *	4.86	4.26	281
Number of Professional Contacts, by Location of Contact			
3. Within the Location	2.38	2.56	275
4. Outside the Location **	2.48	1.90	275
5. DCs **	1.09	0.71	275
6. LDCs, Excluding Local Contacts	0.65	0.61	278
7. Kenya	2.38	2.19	86
8. Ghana	3.21	3.50	94
9. Kerala ***	1.42	2.29	97
10. India outside Kerala **	1.66	1.00	97
11. Universities in DCs **	0.68	0.38	275
12. National Research Centers in DCs	0.17	0.16	275
Number of Professional Contacts, by Sector of Contact			
13. Local Universities	0.94	1.19	278
14. Local National Research Centers	0.86	0.96	278
15. Local NGOs **	0.34	0.11	278
16. Local Business	0.08	0.04	278
17. Local Ministries	0.21	0.20	278
18. Multilateral Agencies	0.40	0.29	278
19. Foreign Universities **	0.78	0.46	278
20. Foreign Ministries	0.09	0.10	278
21. Foreign National Research Centers	0.19	0.16	278
22. Foreign NGOs	0.12	0.09	278
23. Foreign Business **	0.04	0	278
24. Indian Universities ***	0.90	0.23	97
25. Indian Ministries **	0.08	0	97
26. Indian National Research Centers	0.58	0.74	97
27. Indian NGO **	0.06	0	97
28. Indian Business	0.03	0.03	97

* p<.10; ** p<.05; *** p<.01.
[a] The frequency ranked from 1: "at least once a month" to 4: "Never".
[b] Keralan respondents reported the frequency of discussions with people outside India.

Table 7: Attitudes of Respondents by Gender

Variable	Male	Female	N
Language Skills [a]			
% Had Difficulties Hearing, Understanding, or Both **	3.77	13.33	287
% Were Hard to Understand **	4.23	10.67	288
% Who Are Aware of the Existence of New Funding Programs since the Earth Summit in Rio in 1992 [a] *	21.76	12.12	259
Attitudes Toward Environmental Conservation [b c]			

New Environmentalism	-0.02	0.07	211
Tiers-Mondisme *[d]	-0.57	0.19	211
in Ghana***	-0.07	-0.70	75
in Kenya	-0.40	-0.02	59
in Kerala*	0.27	0.56	77

* p<.10; ** p<.05; *** p<.01.

[a] Chi-square.

[b] Average standardized factor scores. The factor scores in SAS result from the multiplication of the standardized data vector and the standardized scoring coefficient, for each observation. They have a mean of 0 and a standard deviation of 1. The standardized scoring coefficients are standardized regression coefficients computed from correlation matrices. They predict each factor from the variables. Respondents from international research centers had to be excluded, because they represented too small a category.

[c] T test.

[d] A general linear model of Tiers-Mondisme by gender and country was significant (p< .001), and showed a significant main effect of country (p<.001), as well as a significant interaction effect of gender by country (p<.01). The results below show GLMs of Tiers-Mondisme by gender for each country.