Triple burden on women in science: A cross-cultural analysis

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Science professes the self-acclaimed ideal of 'universalism' and an irrelevance of personal or social attributes in judging scientific claims. However, in actual practice, science has been a male domain, and has a social structure dominated and hitherto regulated by men, in which, women find themselves unwelcome. This creates hidden barriers in the practice of science. Although these barriers take various forms, stressors in the work environment are found in widely different cultures. Here we argue that social organization of science and gender-role expectations create common barriers in diverse cultures of India, Germany and the US. The organizational environment in which science is practised reflects a contradiction between the norms and practice of science and induces a stress, which we call the first burden. The second burden is common to women in most professions, that of managing unequal domestic responsibilities. There is a third burden carried by women in science, that of grappling with a deficit of social capital and relative exclusion from strong networks. The interaction among these burdens induces a 'surplus of anxiety'. The responses to and possible alleviation of a triple burden have also been discussed here.

Keywords: Exclusion, gender, interaction, social capital, work environment.

AMONGST all professions, women in science alone face the contradictions of a theoretical framework that denies discrimination and proclaims universalism. Studies in different countries, including those by Stolte-Heiskanen[1] (Finland), Hicks[2] (the Netherlands), Tabak[3] (Brazil), Osborne[4] (Germany) and Abir-Am[5] (USA) indicate that there are common barriers to women in science in differing economic, social and educational systems. A study of 12 European countries[6] shows that while participation of women in higher education ranges from 40 to 50%, they continue to face gender inequities in science. One, the proportion of women is highest in the humanities and the social and medical sciences, and the lowest in engineering and technology; second, the higher one goes up the occupational ladder, fewer the women; third, there is a low proportion of women in leadership positions. Some developing and semi-developed countries, such as Turkey, Brazil and Mexico have assimilated modernization ideology enabling women of upper classes to take up higher education, but traditional gender role expectations and a rigid structure at the workplace constitute barriers to women in science[7].

Thus 'universalism in science' paradoxically contributes to a ubiquitous stress, the converse of the Mertonian norm that ethnic, gender, or other social factors shall not impede participation in science[8]. Here, we delineate the factors leading to stress among women in science in three countries (USA, Germany and India) across three continents (North America, Europe and Asia). The existence of common barriers, as well as a modest cross-national trend towards reform that could be accelerated, is supported by our comparative analysis.

We drew upon data from studies, both qualitative and quantitative, conducted by the authors on the experience of women in science in universities and research institutes in India, Germany and the US (Table 1). The US study included interviews with female faculty members at 21 departments in five disciplines (chemistry, biology, physics, computer science and electrical engineering), and the electronic survey at Midwestern University (henceforth, MWU) included six departments (biology, biochemistry, chemistry, computer science, engineering and physics). The German survey[9] included nine institutes from various disciplines (social and natural sciences) and was also directed at those scientists who had already left these institutes by the end of 1997, which allowed a study of careers of those scientists who made it into Max Planck Society (MPS) as well as their career developments after voluntary or forced departures. In the Indian survey, questionnaires and interview data were collected from the women faculty members at four highly reputed institutes of science and technology, including IIT Delhi, IIT Kharagpur, University of Roorkee (now IIT Roorkee) and Jadavpur University.

The US, Germany and India are at different stages of economic, political and social development. However, there are certain similarities with regard to the position of women in society. Higher education in Germany traditionally has been a male domain. Women were denied access to universities until 1908 and the situation changed only in the 1960s and 1970s, with the beginning of mass education. But the proportion of women in academic posts continues to be less than the proportion of academically qualified women. Given the lack of structured graduate programmes and curricula in Germany, the senior advisors have a huge impact on the formation of networks, distribution of opportunities, and provision of tacit knowledge necessary to successfully advance in science.

Since men occupy the highest and most influential positions, the structure of academic careers has a host of underlying gender-biased career prerequisites and mechanisms. Further, careers in academia and science in Germany are

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Table 1. Nature of data sources

Country	USA	Germany	India
No. of institutes	–	9	4
Type of institute	Public and private research universities (Carnegie I level)	Max Planck institutes	Two central and two state government funded institutes*
Sample frame	Men and women faculty and graduate students	All men and women scientists	All women faculty in science and engineering
Sample size	Eighty-four men and 13 women faculty members of Midwestern University and 400 women faculty and graduate students of other universities	Two hundred and fifty-two scientists, including 95 female scientists	Eighty-two women academic scientists
Tools of data collection	Electronic questionnaire survey at Midwestern University and 400 in-depth interviews of women faculty members at other universities	Questionnaire for a mail survey of scientists	Questionnaire and interview
Type of respondent	Tenured and untenured faculty members and graduate students	All had at least started their Ph D work at MPS	All (but 3) respondents had Ph D degrees
Year of survey	1992	1996–97	December 1999 to September 2000

*The two central institutes are IIT Delhi and IIT Kharagpur; the state-funded universities are University of Roorkee (now IIT Roorkee) and Jadavpur University.

of considerable length, discouraging women from following careers in academic science. Candidates for *Habilitation* (or postdoctoral qualification that makes one eligible for position of professor) are usually 40 years old, signalling that career requirements in science, for example, flexibility and full availability, are incompatible with having children and family.

In the US, while the proportion of women with bachelor's degrees in science and engineering has almost doubled from 25% in 1966 to 47% in 1995, the percentage of women with a Ph D in science and engineering was only 31% in 1995. In engineering[10], their share of Ph Ds is much lower at 11%. During their childhood itself, boys and girls develop different gendered images of scientists and their activities. Conformity to stereotypes is frequently, though subtly encouraged by educators and other authority figures. Women who enter college feel an unwelcome minority, negatively viewed by a majority, and experience isolation. Discrimination in the graduate school is often informal, such as not being taken seriously in research group meeting, or a devaluation of their contributions.

In India, science is considered as a male enterprise. Educational decisions are family decisions. Though science and engineering degrees bring in greater prestige and job opportunities, most families are less inclined to invest family resources in academic achievements of daughters than sons. It is assumed that after marriage, benefits of their education would accrue to their husbands and their family. Many parents perceive a danger in sending girls to predominantly male colleges. Fear of travelling alone across towns, odd hours, long periods of study, and danger of not finding a suitable match (with higher educational qualification and age) constitute barriers to women's science education[11]. According to the recent INSA report[12], 42.5% women are enrolled in postgraduation in science and 15.8% in engineering; enrolment in Ph D is 37.2% in science and 16.5% in engineering. Falling market value of pure sciences has made science less lucrative for boys leading to its growing feminization, while engineering continues to be lucrative and male-dominated. Despite the growing science enrolment, women faculty are a miniscule 7% at prestigious institutes such as IISc and the IITs[12,13]. Their proportion as INSA fellows[12] is a mere 3.2%.

We found that women experience a common 'triple burden' across the continents, irrespective of the cultural differences. An inflexible social organization of science, and gender role expectations work together, producing this triple burden. The problems of working in a hostile work environment result in career-related stress, i.e. the first burden. The second burden is the usual predicament of domestic responsibilities, which fall disproportionately on women. This dual burden forces women to work harder than men to prove themselves. In all the three countries, female scientists also carry a third burden of grappling with a deficit of social capital, the relative exclusion from strong networks and the feeling of being aliens in science. The interaction among these burdens induces a 'surplus of anxiety' among women that is well above the normal stressors of obtaining funds, results and recognition, common to all scientists.

There is a male dominance in numbers and a vertical segregation in the three countries. In the six departments of MWU, women formed 20% of the faculty. They often have official responsibilities of minority status in academia. In Germany, there is a numerical majority of males, especially in higher positions; in 1999 16.4% women in scientific staff of the MPS and only 2% of the MPS directors were women. In India, women scientists form only 7% of faculty in science, with low proportion of women scientists at 'professor' level. Women are rarely present at the higher administrative levels and there have been no women Deans or Directors ever.

There is also a horizontal segregation. At MUW, 57% of female researchers are in biochemistry and 21.4% in biology, while none in computer science. In Germany, only 9% of female researchers are in engineering, and 27% in humanities and social sciences. In India, no woman scientist was found in mechanical engineering departments of the institutes surveyed. Women candidates who qualify the Joint Entrance Exam of IITs (for admission to undergraduate courses) cannot opt for the course on mining, because Section 46(1), Mines Act of 1952 of the Government of India does not permit them to do their practical training.

There is a general male dominance in the work environment. In the US, women's personal obligations are taken into account while these are ignored for men while hiring them. Gap in academic career due to childbirth and rearing is expected to be ignored, but it is taken into account. Tenure may be denied for being proactive on behalf of women students. Invisibility, denial of professional identity (e.g. young woman faculty member mistaken for a secretary, student or technician by hostile older members), and neglect by colleagues is commonplace.

In Germany, women are seen as risky employees who may at least temporarily drop out. Ignoring a woman's contributions in discussions, lesser recognition of their performance, preference of male scientists when better or tenured positions are available distributed, were reported. Women are sent less to professional meetings.

In India, the appointment and promotion committees bring up family issues and question women's commitment to the job. Exclusion from certain tasks, such as field work, not being given charge of some engineering section because of gender role stereotypes, underestimation of performance (only 34% respondents reported that their performance is correctly evaluated), condescending attitude of colleagues, male students preferring male advisors, etc. were reported[14]. There is a high degree of visibility due to minority status, leading to an exaggeration of mistakes and stigmatizing women as a whole. Exclusion from administration deprives women of a chance to build up contacts, to prove themselves, and to make the administration more gender-sensitive. They have to work hard to prove their capabilities due to gender stereotypes in the work environment.

In the US, there is a conflict between biological clock and tenure clock. The MWU survey showed that a significantly larger number of women than men participate in the tenure race, without having children. Giving priority to the family is considered a virtue in a woman. In Germany, women scientists with children reported double burden of career and family responsibilities being forced on them. Women scientists without children *anticipated* low chances of combining career with family. Women scientists regard partner's career as more important than their own and institutes see combining family and career as a 'private affair' of women.

In India, traditional norms add to the social obligations due to marriage, and women have greater domestic responsibilities than their spouses. Women publish more after the age of 50 years, which indicates that they often postpone rigorous research to take care of the family.

There is exhaustion in managing a home and career. Women lack time for informal communication and activities that lead to building up of contacts. They may also face a break in career due to pregnancy. Women have to often forego opportunities to travel regarding assignments, conferences, etc. Often they scale down their ambitions to accommodate their family.

Women reported lower levels of colleagueship and reciprocation in the department relationships than do their male peers and typically lack strong networks essential for academic success in the department.

In Germany, women are less likely to stay in science than men; however full support increases the chances of their staying. External support is more important than internal support, but women scientists are unable to capitalize on external support for career development due to traditional assumptions about them. In the scientific labour market, taking a women is considered 'risky' with stereotyped assumptions about their aptitudes and expected skills.

The Indian study also reported exclusion of women from informal networks. About 65% of the respondents felt that contacts with successful professionals outside the institutes are not easily available to women. Some respondents reported use of embarrassing language in tea clubs, exclusion from old boys' networks, and a 'male culture' in departments with a few woman faculty members. Interaction with male colleagues is more problematic in India than in the West, due to traditional role expectations and gender segregation norms.

Exclusion from interaction led to a lack of collaborations, contacts and recognition. The threat of not being taken seriously, exclusionary experiences, dependence on hostile colleagues or seniors, conflict between gender roles and scientific roles, and silence surrounding women's issues produce anxiety that interferes with scientific production and recognition.

Triple burden erodes a feeling of belonging in science, breeds isolation and discourages women from a full utilization of their potential. Female scientists in Germany report having been told that they 'must understand that [male] Ph D students are not willing to take orders from a female superior'. They suffer discriminatory comments by peers and superiors. A male superior who neither invited nor hired female scientists explained: 'I do not employ women with my group. First, if I invite a female and do not hire her, I will have to discuss that matter with the Institute's personnel board (*Betriebsrat*) and justify my decision. Second, since my research is funded by grants, there will be no money for a replacement if the female scientist is getting pregnant during the project period'.

The erosion of self-confidence begins with an attitude promulgated by faculty and co-opted by male peers that women are less competent. A woman faculty member in a premier Indian institute remarked, 'Men colleagues take a long time to see that a woman is equally competent'. Such doubts extend to questioning her ability to even teach a class of boys, as reported by a few women faculty members in India. There are every-day slights, such as being left out of study groups, being ignored in class, lab meetings, not being included in conferences, and being mistaken for a secretary. Insufficient bathrooms and a lack of proper maintenance of them have been noticed in the US as also in India[13]. Disregard of such a basic need sends a powerful message to many young women and women faculty that they are not welcome or expected to succeed.

Gender stereotypes in science and contradictions of norms and practice lead to anxiety on the part of a woman scientist to continuously prove her worth. As an Indian woman professor in the Department of Electrical Engineering said, 'It is generally taken for granted by the men scientists that a woman cannot be as good as or better than them. So women have to work harder than men to prove themselves'. In such an environment where science is not only male dominated but also considered unfit for women, a woman scientist typically faces the contradiction in roles of a 'woman' and a 'scientist'. In the German survey, male scientists maintained that successful female scientists 'turned into dragons' and were in their opinion, 'women not anymore'. Many Indian respondents remarked that women who speak their mind or who are assertive are considered 'unwomanly', and colleagues expected them to be submissive (a common expectation from women as a part of patriarchal ideology). As one Indian woman professor said, 'Some men colleagues initially wanted to force their views on me; they thought that being a woman I should simply agree to their viewpoint'.

To find acceptance among the scientific community, some women scientists continue to follow the traditional path of attaining success in science, which is a 'male model' requiring full time devotion to research, early achievement and exclusive identification of oneself with science. However, most women find this model difficult to follow due to their need for diverse identities and marriage–family concerns. This has resulted in the emergence of two sub-groups among women scientists – 'instrumentals' and 'relationals'. The 'instrumentals' are usually older women scientists who conform to the traditional 'male model' and equate gender issues with a lack of commitment to science. 'Relationals' are a new cohort of female faculty who emphasize collaboration and community within their research group and are sensitive to gender bias[15]. Such groupism tends to confuse the issue of achieving legitimacy for different paths of attaining success in science.

The possible responses to triple burden are: (i) women adapting to the existing structure of science; (ii) changing the structure to accommodate women; (iii) women seeking alternative occupations related to science, and (iv) women leaving science. Responses (i), (iii) and (iv) have been the predominant ones, but these fail to challenge the perpetuation of science as a male domain.

Changing the structure requires institutional intervention. Thus, offbeat career track due to an attempt to combine family and career commitments should not be held against women in recruitment and retention. Many women scientists across the countries are unaware of the fact that other women scientists individually share the same experiences. They often do not realize that their problems are produced by the organizational culture of science. Workshops and organized mentoring could help in increasing the awareness of women scientists about these issues, help them counter feelings of anxiety and self-blame, and encourage strategies to cope with the situation.

The Indian Constitution guarantees equality of pay and prohibits discrimination; yet there is little recognition of discrimination against women scientists. There is only a single point on the agenda of 'Science and Technology for Women' in 'Science and Society Programmes' of the Department of Science and Technology (DST) concerning women scientists[16]. However, recent years have witnessed the government's concern for women scientists. Recently, DST has introduced a scheme enabling women to reenter their career in science after a break[17]. Compilation of the recent report by INSA on women in science[12] is a significant step to gather information, without which bias cannot be understood. However, much more needs to be done.

In Western countries, periods of shortfall in scientific personnel prompt governments to enhance women's participation in science. In Germany, the MPS has implemented programmes to raise the number of female scientists among directors and group leaders (C4- and C3-Sonder-programme of the MPG). However, without financial and institutional commitment and support these programmes may be considered as 'quota programmes', thereby devaluing those positions and stigmatizing its occupants.

One of the keys to mitigating the triple burden on women academics lies in university-wide policies on child-care, parental leave and slowing of the tenure clock, including flexible work schedules and financial help with childcare. 'Critical mass' was expected to be achieved in the US through affirmative action programmes. However, due to subtle biases and exclusionary practices built into the university system, a mere 'supply side' approach is insufficient. The recent controversy over Harvard President Lawrence Summer's remarks about possible biological causation of gendered differences in scientific achievement has led several universities, including Harvard, to seek to remove barriers to advancement of women[18].

Department review (with outside referees) for diversity issues should evaluate recruitment, hiring and retention of women in the departments. Such reviews could also be used as a component of a 'diversity' category to publicly rank departments. There is continual pressure to fill gaps and improve academic rating schemes. Despite, or even because of controversy, the US News and World Report, and its counterparts, carry great weight and drive changes to meet their standards. The modest proposal above could recognize departments and schools that have succeeded in lifting the 'triple burden'.

Our analysis confirms the findings of various authors on women in science in different countries, that there is gender-related discrimination and stress in the practice of science. It is apparent that the stress is a product of similar reasons: a lack of universalism in science, undue burden of domestic responsibilities and lack of informal networking. Among these, while domestic burden is a product of gender stereotyping, the other two arise from the social organization of science. However, social norms related to gender infiltrate the organizations where science is practised, and the three are therefore interrelated. The common triple burden proves that the culture of science and the universal gender role schism is responsible for a low position of women in science across continents.

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Salt stress effects on the accumulation of vacuolar H^+-ATPase subunit c transcripts in wild rice, *Porteresia coarctata* (Roxb.) Tateoka

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The ion pump, vacuolar H^+-ATPase (V-ATPase) plays a major role in the maintenance of cellular pH, and influences the transport of cations into the vacuoles of plant cells. A cDNA clone (*PcVHA-c1*) encoding the c subunit of V-ATPase was isolated from the salt-tolerant wild rice, *Porteresia coarctata*. The DNA sequence of *PcVHA-c1* showed significant homology with V-ATPase subunit c of rice. The deduced amino acid sequence of *PcVHA-c1* and other reported c subunits were compared, and sequence relationships have been drawn to know their genetic relatedness. Southern analysis suggested the presence of multiple coding regions for subunit c in *P. coarctata*. Northern and Western analyses of salt-treated *P. coarctata* plants revealed that subunit c of V-ATPase is upregulated by NaCl treatment at both transcriptional and translational level.

Keywords: *Porteresia coarctata*, salt tolerance, subunit c, V-ATPase, wild rice.

TONOPLAST of the plant cell separates the vacuole from the cytoplasm. Specific proteins present in the tonoplast drive the transport of ions and other metabolites across it[1]. The selective transport properties of the tonoplast are central

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