THE GENDER REVOLUTION IN SCIENCE AND TECHNOLOGY

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The confluence between the gender and information technology (IT) revolutions has the potential to create a new development paradigm. The transition from an industrial to a knowledge society opens up new opportunities for women in the emerging technology transfer, innovation and entrepreneurship (TIE) fields that avoid some of the negative consequences of academic science. The spread of information and communication technologies (ICTs) in developing countries empowers women by upgrading skills, enhancing employment opportunities, creating income for reinvestment and political strength. This article addresses the consequences of gender inequalities in depressing the contribution of women and the growing opportunities for them to use technology in order to take economic and social advancement into their own hands.

The gender revolution in science and technology (S&T) is uneven but not stalled.[1] It moves in fits and starts in a positive direction, with exceptions such as the downward trend in computer science education.[2] In a broad range of disciplines, women in both the developed and advanced developing worlds (e.g., Brazil, Chile, Argentina and South Africa) are moving to parity in access to higher education in S&T. Recently, women have attained top leadership positions in science and technology at major universities (including Harvard University, the Massachusetts Institute of Technology (MIT), Princeton University, Cambridge University, the Swiss Federal Institute of Technology, Zurich and Chalmers University of Technology, Gothenberg), suggesting a gender breakthrough.[3]

The gender digital divide is also waning, with women's access to computers and

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mobile telephony increasing across the globe. The $100 laptop from MIT's Media Lab has been outdone by India's $35 model, putting computing technology within reach of even more people. Access to technology in Indian villages has allowed women to improve their economic condition, advance politically and broaden S&T participation for future generations. The fictional female hacker in Steig Larsson's *The Girl Who Played with Fire* may portend a real life trend.[4] Indeed, with boys falling behind girls in a variety of academic fields in developed countries, we may expect calls for reverse affirmative action.[5]

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Despite progress, the steady increase in participation of women in science is marred by the tendency of fields to lower in status as women achieve equality of representation, and by continued resistance to women reaching positions of authority. Thus, while "[g]ender equality in Brazilian science is increasing up to doctoral level...few women hold senior scientific posts," the last frontier of gender inequality.[6]

Most men, and some women, deny that exclusionary factors exist. Thus, women in science bear a triple burden:

- The contradiction between the norms and practice of science and the organizational environment in which science is practiced;
- Domestic responsibilities, which fall disproportionately on women; and
- Lack of social capital (i.e., the relative exclusion from strong networks and the feeling of being outsiders in the field of science) and over-reliance on human capital.[7]

As the gender revolution evolves, new vistas appear in the transition from an industrial to a knowledge-based society, bringing increased opportunities for women in the emerging technology transfer, innovation and entrepreneurship (TIE) fields. TIE provides an alternative path that enables women to avoid some of the negative social and psychological consequences of academic science's gendered structures.

In this article we address the consequences of gender inequalities in depressing the contribution of women and the growing opportunities for them to use technology in order to take economic and social advancement into their own hands, mostly exemplified through studies from India.

Surplus Anxiety for Women in Science

Women scientists have believed the scientific community's philosophy that, as scientists, their work will be judged on merit alone. The theoretical framework of the scientific enterprise could not afford to base the "acceptance or rejection of [scientific] claims....on the personal or social attributes of their protagonists: his race, nationality, religion, class and personal qualities are as such irrelevant."[8] Reflective of the era, Merton referred to scientists as "he" and "him." In an unanswered letter, historian of science Helene Metzger wrote to Emile Meyerson, her senior contemporary in 1933, demanding to be accepted as a professional equal: "In the Republic of minds, we are all equal and you must prove that reason is on your side, not impose it by force or by intimidation."[9]

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Surplus repression can be defined as "the restrictions necessitated by social domination. This is distinguished from (basic) repression: the 'modifications' of the instincts necessary for the perpetuation of the human race in civilization."[10] Surplus repression and anxiety reinforce each other, depressing the advancement of women in academic science. Women scientists face role overload and social capital depletion above and beyond the normal stressors of a scientific career. This produces a surplus of anxiety, requiring expenditure of personal and psychic resources that exceeds the effort normally required to compete in a demanding profession.[11] The anxiety induced by gendered structures inevitably demands psychic energy, thus making unnecessarily difficult the production of good science that might otherwise occur in a less stressful environment. Though some stress is inevitable and even productive—the so-called creative tension of the best scientific workplaces—too little, and especially too much stress, is counterproductive.[12]

Women's experiences in scientific academia in the United States are often fraught with concerns about not being taken seriously, exclusionary social dynamics, dependence on hostile colleagues or seniors, pressure to emulate the male model of doing science, and the requirement to fulfill the role of the token woman on committees. Women are also expected to act as role models for students and to maintain silence about gender disparities. These experiences impede interpersonal connections and obstruct women's ability to fulfill their potential, no matter how gifted they are. The *Athena Unbound* study shows how marginalization, rejection and diminishment produce an anticipatory state of vigilance, compelling women to work harder to prove themselves.[13]

All anxiety is fear-based, including anticipatory anxiety. Women and men

flourish best in those institutions where inclusion and recognition—I am seen, I am heard, I am known—is the ethos from the top down, or those labs or firms where the environment is collaborative and inclusionary. In the absence of a constructive environment, women's networks and support groups may partially replace the interpersonal interactions lacking in the broader organizational structure. Nevertheless, such groups cannot fully mitigate the corrosive quality of diminishment and dismissal. The question is, can these networks create social change from the bottom up without top-down organizational change? Although the individual is experiencing the anxiety, it is the interpersonal matrix that produces it. Take away the environmental stressors, and anxiety decreases.

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Using IT to Women Scientists' Advantage

Women academic scientists use information technology (IT) to overcome isolation, patriarchal organizational structures, lack of mobility and other constraints that hinder professional advancement.[14] The use of information and communication technology (ICT)—particularly the Internet—has the potential to limit the negative consequences that arise from these constraints.

ICT plays a significant role in the professional and personal lives of female academic scientists in India by helping them sidestep barriers related to limited travel and social interaction. Women can use the Internet to gather information for project proposals without moving around to do so. The Internet also facilitates participation in foreign conferences and workshops through direct contact with the organizers. Moreover, the Internet enables women scientists to transcend distance in their personal communications and maintain regular contact with their kith and kin while traveling, thus allowing them to fulfill traditional obligations.

In Kerala, India, for example, the Internet and the presence of home computers have helped trigger a process of circumventing traditional gender roles that restrict interactional opportunities because of the need for women to fulfill domestic household obligations and, in some cultures, the taboo associated with inter-gender contact.[15]

In parts of Ghana, Kenya and India, however, the Internet has not improved women's productivity.[16] Men tend to be more successful with regard to scientific publications owing at least in part to their educational and travel experiences in foreign countries. Thus, the Internet, "while helping to circumvent the inter-

national isolation of female researchers, has not yet improved the size of their external networks."[17]

Although technology cannot resolve gender inequities arising at the organizational level or alter patrifocal norms, it helps women overcome constraints that are typically greater in developing countries, thereby ensuring a more level playing field for women to compete with men.

Innovative Solutions for Inclusion

In Western countries, periods of shortfall in the supply of scientific personnel have prompted governments to enhance women's participation in the field. Affirmative action was expected to achieve critical mass in U.S. academic science through substantial participation of women and minorities.[18] However, given subtle biases and exclusionary practices, supply-side approaches are insufficient.

Wider organizational and departmental policies are required, such as recruitment into pivotal positions and to important committees so that women can develop a network of contacts, access inside information about organizational politics and gain visibility. Internal and external reviews of departmental diversity can identify inequities in the recruitment, hiring and retention of women. These reviews can also be used to rank departments. Organization-wide policies on childcare, parental leave and slowing of the tenure clock, including flexible work schedules and financial help with childcare and housework, can mitigate the triple burden.[19]

Gender prescriptions are not immutable. An alternate model of conducting science incorporates cooperation and communal qualities. An Italian female scientists' childcare collective evolved into a research group that directs a European project, exemplifying this ideal.[20] Many young female faculty and some young men emphasize collaboration and community in their working environment. Some male advisors are excellent mentors to all their students, regardless of sex, and may be more helpful than some female faculty who follow the male model of science.

But the two worlds of male and female science remain largely separate.[21] Given the propensity of scientific establishments to deny discrimination in their midst, the causes of the shortfall of women in senior positions are typically left unexplored, even when the gap is noted.[22] Further down the academic ladder, caste barriers are more explicit, causing some women to turn their scientific interests away from academia.

The Vanish Box of Women in Science

A significant phenomenon is emerging at the intersection of science and economy: highly skilled female scientists are pursuing careers in technology

transfer and other science-related professions that we call the vanish box. Vanish box dynamics are characterized by reappearance from the reserve army of underemployed female scientists and include a complex mix of linear and non-linear trajectories, different from the traditional linear career path that is commonplace among male scientists. Women who migrate to science-related professions utilize their skills in new cross-border occupational areas that translate knowledge into economic and cultural activity. Multidisciplinary knowledge-based professions integrate both technical and relational skill sets and do not fit the parameters of traditional single-gendered occupational roles.

Technology transfer is a hybrid role that incorporates elements of science and business in its professional design, bridging the gap between invention and the creation of new economic activity. In addition to formal transfer, technology transfer includes sensitizing researchers to the commercial implications of their investigations, assisting in new business development, participating in regional development organizations and formulating policies to regulate commercialization. Technology transfer professions are moving from peripheral support structures to core competencies in corporations, government labs and universities.[23] This provides an opportunity to break with previous patterns and set new ones that are more conducive to gender equality. TIE enhances the contribution of S&T to economic and social development, and provides relief from surplus anxiety.

Recent evidence provided by a pioneering four-country study conducted for the European Commission analyzes patterns in TIE professions:

- Broadly gender-neutral, with recruitment and promotion most often focused on and rewarding the best person for the job;
- Good work/life balance, flexible working practices and family-friendly environment benefiting both female and male employees;
- Age and experience, career breaks or changing career direction less penalizing than in academia or business;
- Positive perception of TIE work as socially beneficial, highly interactive, enjoyable and satisfactory; and
- Lower importance of so-called old boys' networks and increasing weight of women's networks targeted at a wide range of businesswomen.[24]

Interface professions such as technology transfer emerge from a major change in the relationship between science and the economy.[25] As the intermediation among institutional spheres becomes significant for economic development, "women's movement into technology transfer...makes them increasingly important players in innovation."[26] Gender equality is facilitated by the relatively small size and flat structures of TIE organizations (e.g., technology transfer offices, science

parks and business incubators), though the ability to offer continuous career paths and career advancement is limited, with the notable exception of spin-off entrepreneurship. Nevertheless, the strength and persistence of women's advancement in these professions need further investigation.

TIE provides a strategic research site to investigate the emergence of gender equality in the occupational structure of the knowledge society, with implications for restructuring academia and business. TIE's mix of advantages and disadvantages includes a wide range of responsibilities and considerable work flexibility, but also lower pay and relatively few in-house career opportunities. Given that many women work part-time, the intersection of career and flexibility appears to be a double-edged sword, but flexible work schemes improve the work-life balance and preserve career advancement opportunities.[27]

When new occupations and professions are created, they are typically more open to women's participation and advancement. In the past, women tended to disappear from leadership positions as scientific and technological fields rose in status. However, this traditional pattern may be changing in TIE due to the movement for gender equality and the need to fully utilize human resources.

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Closing the Development Divide

Growth in TIE signifies the movement of societies toward a knowledge economy in which innovation, including the translation of science into economic activity, is crucial. Developing countries increasingly recognize the need to diffuse scientific and technological knowledge as part of a development strategy of institutional transformation. Application of ICTs thus becomes critical, which in turn has implications for women's advancement. However, there is a gap between those with and those without good access to ICTs, particularly between advanced industrial and developing countries. The digital divide exacerbates race, class, ethnic, age, religious, gender and rural/urban differences. It becomes acute not only due to infrastructural deficiencies and poor penetration of the Internet, but also due to lack of basic literacy. For example, women represent only 23 percent of India's Internet users.[28] "Women have reduced access to ICTs for a number of reasons, ranging from sociocultural attitudes and preconceptions about women's interaction (or lack of it) with technology to resource constraints."[29]

Moore's Law postulates inexorable reduction in costs of integrated circuits, the basic building blocks of computers and IT equipment, making them potentially

more accessible to less well-to-do countries and persons. An ICT revolution that had been largely confined to highly developed countries may thereby broaden. Both high-level scientific equipment and simple mobile telephony devices follow Moore's Law. Universities heretofore limited to teaching may acquire state-of-the-art research equipment enabled by low-cost computers and IT. Small and medium-sized enterprises (SMEs) and even micro-enterprises are increasingly able to access basic computer and communication tools at modest cost.

To reduce the digital divide between the industrialized and developing countries, the latter have adopted various strategies for the diffusion of ICTs. These strategies involve both production—hardware or software development—and consumption—e-commerce and e-governance. The liberalization and privatization policies of the government of India since the 1990s have spurred IT industry growth.[30] An important element in the growth of the software industry has been the establishment of Software Technology Parks (STP).[31] With no special focus on the role of women, this market-oriented strategy has been adopted by a number of states that have set up technology parks resembling STPs. E-government initiatives also include significant attempts to diffuse ICTs into rural areas.

Weak technological determinism can only make opportunities available; it does not by itself guarantee that knowledge and skills will be acquired, nor does technological innovation ensure that institutions and norms will change to enable new tools to be put to use by all who need them. Nevertheless, the intersection between the IT and computer revolutions and the gender and feminist revolutions opens new vistas for the empowerment of women in developing countries. The following section discusses how these two increasingly intertwined revolutionary forces are converging in India through a combination of top-down and bottom-up initiatives.

Technological Empowerment of Women in India

Empowerment may be understood as the ability to make strategic life choices in the context where this ability was previously denied.[32] It involves changes in the allocation of roles, resources and power in various aspects of society. Such changes require not only development planning or a top-down approach, but also active participation of women themselves. The organizations operating at grassroots levels should enable women to fight against injustice.[33] Empowerment takes the form of upgrading skills, increasing employment opportunities, generating income for reinvestment and changing the gender equation in terms of women hiring men, women taking on managerial jobs and women being elected to local councils in India.

For the majority of women in India, barriers include illiteracy, unfamiliarity

with English or other of the dominant languages of the Internet, lack of computer skills, disproportionate domestic responsibilities and lack of utility for the information attained through ICTs. Infrastructure is also more developed in urban areas whereas most women live in rural areas.[34] Sociocultural factors include opposition to women's access to technology education, lack of income to use public Internet facilities, inconvenient location of such facilities along with security concerns about frequenting them at night, and little leisure time.[35] While public use of the Internet via cybercafés has the potential to bridge the gender divide in urban India, Internet kiosks in rural areas have tended to disproportionately serve the interests of those who are better off.[36]

Gender Digital Divide: Policy and Practice

There are two approaches to the discourse on the information society. One is the use of technology and ICTs for creating greater economic advancement through the liberalization, globalization and deregulation of all aspects of technology use and transfer. The assumption in this case is that economic benefits will be reaped by all, including women.[37] The second approach is to view technology as a tool for development and a vehicle for social change. It aims at building empowering conditions through which existing power relationships are challenged. This second approach has the potential to transform the gender equation in society. Governments of states in India such as Kerala, Gujarat, Tamil Nadu and Andra Pradesh have initiated innovative interventions in ICTs that are at various points in the spectrum, from gender-neutral to gender-focused. Gender relations are altered within larger institutional systems in the developmental context of ICT for development (ICT4D) projects and contribute to positive gender outcomes, beyond access and numbers.[38]

Gender consequences of ICTs are strongly related to the context in which ICTs operate and may be broadly examined at two different levels. First, the consequences of increased demand for software labor directly impacts women's employment in the market-oriented mainstream ICT sector. Second, innovative state interventions have led to development of ICT-based enterprises run by women in rural areas. It is estimated that, while women constituted only 13 percent of the national labor force in 2001, their participation in the ICT sector was higher, constituting 21 percent of the total IT workforce.[39] At present, women constitute approximately one third of the total IT workforce.[40] The total number of IT and IT Enabled Services (ITES) and Business Process Outsourcing (BPO) professionals employed in India is estimated to have grown from 284,000 in 1999–2000 to 1,287,000 in 2005–06, and by over 230,000 in the one year period between 2004–05 and 2005–06. According to a 2004 survey by India's National

Association for Software and Software Companies, about 74 percent of software professionals in software companies were men, whereas 26 percent were women. The ratio of males to females in the ITES sector is reversed (i.e., 31:69).[41] In financial year 2009, women constituted more than 30 percent of the total employee base in the IT-BPO industry.[42]

While mainstream ICTs (software and services) create opportunities for women, they also reproduce gender inequalities.[43] Women are catching up in ICTs in many developing countries and are close to attaining parity in numbers with men in the Malaysian software sector. There is, however, vertical segregation as women are usually clustered in the low-skilled level of the hierarchy with little potential for career advancement due to absent skills.[44] Male workers dominate the technical and managerial occupations. In Brazil, male teachers of technical disciplines tend to steer women toward so-called female-appropriate work in software, graphics and desktop publishing, while hardware design and maintenance is considered men's work. In Africa, Cisco Systems Networking Academy Program found that employers perceive women as unqualified for networking jobs because of the supposed physical demands of the work.[45]

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Women in the Indian IT industry are concentrated in those areas that require routine or discretionary skills. Women are less visible in the specialized areas of back-office operations.[46] Significantly fewer women than men tend to be project leaders or managers.[47] Women received fewer skill development opportunities within their workplace than men in a technology park at Kerala.[48] Moreover, gender assumptions were built into competencies required for work. For instance, men were seen to have greater working flexibility and potential for working under pressure. Since these assumptions were built into the appraisal system, women found evaluation biased and stressful. Further, market-based job flexibility worried women since it failed to offer long-term income security due to absence of pension or provident fund provisions. Thus, the competitive and marketized nature of work in the software sector reproduces gender inequalities.[49]

On the other hand, ICT policies have broader goals of social and economic development. For instance, Rural eSeva kiosks in Andhra Pradesh aim to provide different government department services (e.g., utility bill payments, provision of certificates, e-literacy training courses for children and grievance redressal system) at a single point and place with the understanding that large numbers of centers would be run by youth or women's cooperatives called Self Help Groups (SHGs).[50]

Although this is a top-down approach with limited participation of women, the centers operated by women changed the status of those women from agricultural laborers or lower level marketers to women entrepreneurs who became role models for other women. In many cases, these women stood for elections and became *sarpanch* (head of village *panchayat* or local government). Many more women tended to use centers run by women for paying bills or applying for certificates, which was previously seen as a male domain.[51]

Successful gender interventions require a vision that cuts across government departments and have a gender focus at all stages of the project. Initiatives such as Rural eSeva are largely successful due to dynamic leadership and the ability to secure the cooperation of all government departments. For example, some elements of the project weakened after a key government official was changed. In this case, the elements that fizzled out were the grievance redressal system (which helped unearth corrupt practices) and the strengthening of market linkages for products produced by SHG groups.[52]

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Some ICT project initiatives are gender focused, incorporating gender as an essential part of project. For instance, *kudumbashree* (meaning 'prosperity of the family'), an initiative of the Kerala State Poverty Eradication Mission (SPEM) launched in 1998, is a women-oriented, participatory and integrated approach to fight poverty.[53] Each *kudumbashree* unit, or neighborhood group, is a cooperative of about ten low-income women operating both as enterprise and microfinance organizations. The enterprise takes different forms, from processing of agricultural produce to use of ICT. *Kudumbashree* units, all cooperatively owned, are managed and operated by women from poor families. The program has 3.7 million members and covers more than 50 percent of the households in Kerala.[54] At present, there are 203,000 *kudumbashree* units, both rural and urban. Among these are three types of ICT-based enterprises, including those providing IT training to schools, data entry and digitization units, and hardware assembly/maintenance units. One such unit undertakes data entry work for state government departments, CD rewriting, website maintenance and IT training in a number of government schools. Additional staff, including men, have been employed apart from the original ten women members.

These units have created jobs for thousands of women, many of whom possess high educational qualifications and have enhanced their personal and professional skills. Surplus funds have been generated for re-investment even though self-

sustainment is difficult without ongoing institutional support. Such interventions have empowered women, who perform all of the managerial roles in the enterprise, overseeing both men and women. A number of women from these units have been elected to local government councils.

Innovative use of technology, when built in with institutional arrangements and interventions, can go a long way in creating enterprise opportunities for women at grassroots level and create an environment that changes the gender equation.

Women Empowering Women

Here, our major concern is how information technologies are used to transform institutions for greater gender equality. Some non-governmental groups, including NGOs and women's business groups, have incorporated the use of ICT4D through collaboration with mainstream institutions and government. They have been helpful in improving the professional and personal lives of women at the grassroots level, as demonstrated by the success of the Development of Humane Action Foundation (DHAN).[55] DHAN, in Madurai, Tamil Nadu, is a trust employing ICTs in rural areas for providing commercial and development services to the villages. These include computer education at low cost, such as hardware, e-governance, eye care applications, agriculture information, innovative technologies for grassroots development in agriculture and animal husbandry, emailing, browsing and e-commerce. It has set up village information centers (VICs) or rural kiosks with the involvement of women's self-help groups who run the centers as a business.[56]

Women are the operators of VICs. Operators gather information on the needs of the community and create awareness about how VICs can be useful to households. This has led to the empowerment of operators in their personal lives.[57] DHAN has 162 centers running in Tamil Nadu and a majority of its staff consists of young women.[58] As increasing numbers of young women gain experience and facility with technology in the developing world, it may be expected that larger numbers will seek formal training in S&T.

Finally, women in small-scale business have attempted to encourage their own rural women members to use ICTs for the betterment of their lives. For example, the Self Employed Women's Association (SEWA) combines IT with small-scale business, with village officials providing space and support. SEWA's Trade Facilitation Centre (STFC) is a coordination unit providing access to better prices and markets. The Community Learning Centers (CLCs) at village level are

linked to STFC services. While STFC has helped in enhancing livelihood opportunities for women artisans and traders in Gujarat districts, CLCs serve as a hub for all of SEWA's grassroots activities providing computer training, information on education, health, credit, skill upgrading, VSAT (satellite technology) enabled tele-agriculture and tele-natural management applications. Innovative use of technology, when built in with institutional arrangements and interventions, can go a long way in creating enterprise opportunities for women at grassroots level and create an environment that changes the gender equation. Such enterprises have a ripple effect, as women entrepreneurs involved in them become role models for other women of the community.

As economic growth becomes more dependent upon S&T, gender issues in S&T become central to gender equality.

Conclusion: Gender Revolution and Devolution

Change and equality, when they occur, should be a focus of attention, with ways sought to expand upon successful experiments.[59] What mechanisms are currently constructing gender equality? The U.S. National Science Foundation Advance Program and the European Union's gender and science initiatives, along with the various Indian initiatives discussed above, have helped effect change. Top leadership makes a significant difference when it is pushed by bottom-up initiatives. In the wake of the Larry Summers debacle in 2005, Harvard University's administration was forced to attend to negative gender cultures, professionalizing the process of change.[60] The vanish box suggests an alternative perspective on gender attrition to both the pessimistic leaky pipeline view of permanent loss of women in science and the more optimistic, but disconfirmed, pump priming expectation that, as increasing numbers of women enter scientific professions, a smooth generational change will occur in which women rise to leadership positions proportionate to men.

As economic growth becomes more dependent upon S&T, gender issues in S&T become central to gender equality. Their flow through normal channels impeded, women in science find ways around blockages. The rising tide of women educated in S&T and experienced in the use of technology expresses itself through entry into the newly created intermediary professions linking science and the economy.[61] As the utilization of knowledge becomes as important as its production, TIE fields are expanded and revalued, with significant implications for gender equality. These new fields are not plagued by the conditions producing surplus anxiety in traditional scientific and technological regimes.

The application of ICTs is significant to development worldwide and has

gender-related impacts. IT workplaces in both developed and developing countries are often toxic environments that exclude women.[62] However, women in the mainstream market-oriented IT sector can gain much if the gender-blind approach is transformed into a gender-sensitive one. Some organizations in India have established flexible office hours, policies allowing women to work from home, adequate maternity and paternity leave and on-site childcare facilities, and allowed workplace unions. Mostly confined to multinational software companies, these practices are not yet commonplace. While mitigating the dual burden, issues arising from gender stereotypes remain to be addressed.

The innovative institutional interventions, exemplified by the Indian cases, have maximum potential for generating employment and entrepreneurship among women and creating gender impact. However, these can be achieved only by weaving the gender dimension at every stage of the project, as a significant component of the project itself. Although these interventions have emerged in an entirely different institutional context and may not be applicable to other settings, they lead to important conclusions, such as the need for a gender focus and top-down initiatives accompanied by a participatory approach. They provide an insight into the manner in which technology can be employed to reduce gender inequalities. The confluence of the gender and the technological revolutions circumvents the need to overcome the deficits in each revolution separately. ♔

NOTES

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