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Rafael Castillo, Matteo Grazzi, and Ezequiel Tacsir

Abstract*

Skill gaps are a key constraint to innovation, hindering productivity growth and economic development. In particular, shortages in the supply of trained professionals in disciplines related to Science, Technology, Engineering, and Mathematics (STEM) may weaken the innovation potential of a society. A wide gender gap has persisted over the years at all levels of STEM disciplines throughout the world. Although the participation of women in higher education has increased, they are still underrepresented. Latin America is no exception. The untapped potential of fully trained and credentialed women represents an important lost opportunity not only for women themselves but also for society as a whole. Although there is growing recognition of the importance of the issue in developing countries, Latin America faces a lack of information that prevents researchers from deepening the understanding of this phenomenon and policymakers from designing effective interventions. This note aims to contribute to the academic and policy debate in the region by reviewing the main factors put forward in the literature to explain gender inequalities in recruitment, retention, and promotion in STEM disciplines and by providing evidence of the scope and results of policies directed to obtain a better gender balance in the sector.

JEL Codes: J71, J45, O38
Keywords: Science and technology, occupational choices, gender discrimination, academic promotion

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1. Introduction

Skill gaps are a key constraint to innovation, hindering productivity growth and economic development. In particular, shortages in the supply of trained professionals in disciplines related to science, technology, engineering, and mathematics (STEM) may weaken the innovation potential of a society. Empirical studies show that countries with a higher proportion of engineering graduates tend to grow faster than countries with a higher proportion of graduates in other disciplines (Murphy, Schleifer, and Vishny, 1991). In addition, future technical change is likely to be linked to abilities and tasks related to STEM disciplines.[1]

A wide gender gap has persisted over the years at all levels of STEM disciplines throughout the world. Although women have made important advances in their participation in higher education, they are still underrepresented in these fields. This problem is more acute at the senior-most levels of academic and professional hierarchies.[2] Latin America is no exception. Although 60 percent of tertiary graduates and 45 percent of researchers in Latin America are women (UNESCO, 2007) - surpassing all other regions, including Europe (33.9 percent), Oceania (39.2 percent), and Asia (18 percent) - in STEM disciplines this percentage drops to 36 percent. Only 11 percent of Latin American female graduates of tertiary education are in STEM fields, while STEM fields represent 12.3 percent of new enrollments at the tertiary level (UNESCO UIS database). Moreover, participation of Latin American women at the higher strata of research is rare. For example, while in Brazil 49 percent of researchers are female, only 27 percent of women lead research groups, compared to 32 percent for men (CNPq database, 2012).

Gender equality in science, technology, and innovation is not simply a matter of fairness. A more equitable gender balance is believed to enhance the recruitment of the most talented, irrespective of gender (European Commission, 2008a), tapping a partially unexploited resource.

[1] Considering the intensity of five different types of tasks across the wide array of existing occupations (Autor, Levy and Murnane 2003), the evidence shows that the occupations in which employment is rising are those that require a greater intensity of non-routine analytic and interactive tasks, such as frequent use of mathematics and high executive functioning. The U.S. labor market has been moving toward jobs that require skills to complete uncertain and interactive tasks (Council of Economic Advisers, 2009). It is expected that future advances in science and technology will redefine the types of jobs to be performed in the future (Fast Future, 2010). The CEA highlights that at the beginning of the decade more than quarter of American workers were in jobs that were not even listed among the occupation codes 40 years before.

[2] For example, Zynovyeva and Bagues (2011) report that while in Europe women account for 45 percent of Ph.D. graduates, they represent only 36 percent of associate professors and a mere 18 percent of full professors. Similarly, in the United States, excluding the humanities, 40 percent of new Ph.Ds. were women, but only 34 percent were associate professors and only 19 percent were full professors.

A more inclusive workforce is assumed to be more innovative and productive than one which is less so (National Academy of Sciences, 2006). Having scientists and engineers with diverse backgrounds, interests, and cultures assures better scientific and technological results and the best use of those results (Lane, 1999). Gender equality is seen as a way to promote scientific and technological excellence rather than just improving opportunities for women (genSET, 2011).

The untapped potential of fully trained and credentialed women who might be interested in STEM but choose not to pursue degrees in these fields or who decide to change careers because of obstacles, real or perceived, represents an important lost opportunity not only for women themselves but also for society as a whole. Career impediments for women deprive societies of scarce human resources, which is detrimental to competitiveness and development. More research is needed to identify the root causes of gender disparities in these fields and to develop appropriate policy responses.

Although there is growing recognition of the importance of the issue in developing countries, most of the literature on gender inequalities in STEM and the policies designed to rectify them relate to the United States and Europe. Not only are women in Latin America underrepresented in STEM fields; they are also under-measured, and the lack of information has prevented researchers from deepening understanding of the reasons for this gap. It has also prevented Latin American policy makers from designing effective interventions.

This paper aims to contribute to the academic and policy debate in Latin America on gender in STEM. Section 2 reviews the main hypotheses and factors put forward in the literature to explain inequalities in recruitment, retention, and promotion up the career ladder. Section 3 presents the most important policies put in place worldwide to contribute to a better gender balance in STEM fields. Section 4 concludes with final comments.

2. Barriers to the Participation of Women in STEM

A full understanding of the factors constraining women's career paths in STEM has often been hampered by the persistence of several myths and clichés. Table 1 presents some of these commonly held beliefs and contrasts them with existing evidence. The various factors that have been identified in the economic literature at different stages of the career pipeline are then presented (Figure 1). These include: (i) higher education; (ii) stage of career development; and

(iii) scientific productivity. Although some factors specifically affect a particular career stage, several of them are present throughout the career path.

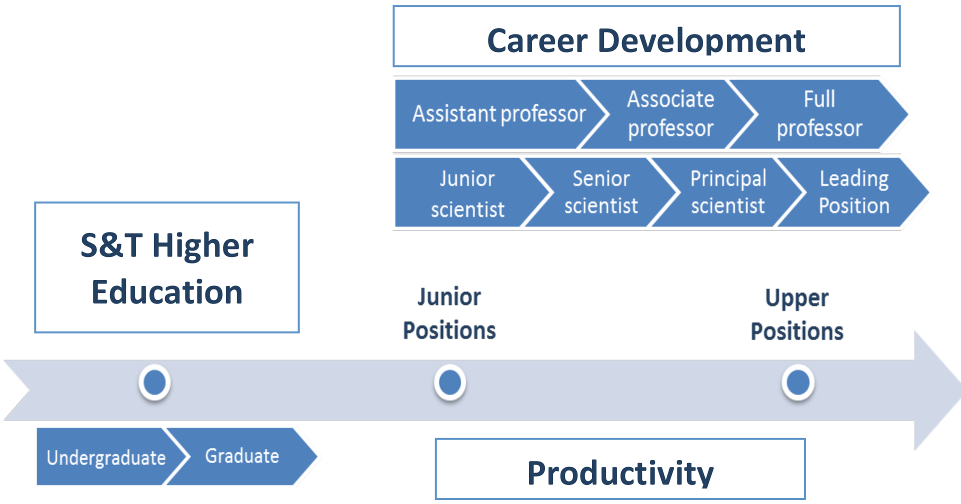
Table 1. Myths about Women in STEM and Evidence Refuting Them

Myth	Evidence
Women don't have ability and drive to succeed in STEM.	• Studies of brain structure and function, hormonal modulation, human cognitive development, and human evolution have not found any significant biological difference in men's and women's ability to perform in science and mathematics (Ceci and Williams, 2007). • In the United States, female performance in high school mathematics matches that of males (NAS, 2007). • Among adolescents in the top 1 percent of mathematics ability, boys are almost twice more likely than girls to obtain degrees in physical sciences and engineering (Weinberger, 2005). Lack of innate mathematics ability could not explain this difference.
The underrepresentation problem in science faculties will be naturally solved with the passing of time.	In the United States, women's under-representation along the academic career is present also in fields that have had a large proportion of female Ph.Ds. for 30 years (NAS, 2007).
Academia is a meritocracy.	• Although scientists like to believe that they "choose the best" based on objective criteria, decisions are influenced by factors—including biases about race, sex, geographic location of a university, and age— that have nothing to do with the quality of the person or work being evaluated. • An article receives less favorable reviews when it is identified as written by a female author (Paludi and Bauer, 1983).
Changing the rules of selection and promotion to foster gender equality means that the standards of excellence and advancement will be adversely affected.	• Throughout a scientific career, advancement depends upon judgments about one's performance by more senior scientists and engineers. This process does not optimally select and advance the best scientists and engineers, because of implicit bias and disproportionate weighting of qualities that are stereotypically male. Reducing these sources of bias will foster excellence in science and engineering fields. • Wenneras and Wold (1997) state that "a woman has to be more than twice as productive as a man to be judged equally competent."

Female faculty members are less productive than their male counterparts.	• The publication productivity of women science and engineering faculty has increased over the last 30 years and is now comparable to men's. The critical factor affecting publication productivity is access to institutional resources; marriage, children, and elder care responsibilities have minimal effects. • According to Sedeño (ed.) (2001), "women are members of low power committees, have fewer financial resources, less support from staff, or are located in offices which are further away, lack access to "beginners' networks" in order to obtain information, and do not have models or mentors to ask for advice or support." • Symonds (2007) finds that funding still depends on the number of papers published, which keeps men at the top.
Women are not as competitive as men. Women don't want jobs in academia.	• Similar proportions of men and women science and engineering doctoral students plan to enter postdoctoral study or academic employment.
Women are more interested in family than in careers.	• Many women scientists and engineers persist in their pursuit of academic careers despite severe conflicts between their roles as parents and as scientists and engineers. These efforts, however, are often not recognized as representing the high level of dedication to their careers they actually represent.
Women take more time off due to childrearing, so they are a bad investment.	• On average, women take more time off during their early careers to meet their caregiving responsibilities. But, by middle age, a man is likely to take more sick leave than a woman.
The system as it currently exists has worked well in producing great science; why change it?	• Career impediments based on gender or racial or ethnic bias deprive the nation of talented and accomplished researchers.

Source: Extracted and adapted from NAS (2007).

Figure 1. Scientific and Academic Career Pipeline



2.1 Higher Education

Although the first interaction with science and mathematics occurs in elementary and secondary education, tertiary education is the critical step in which students decide their future careers.[3] The transition from high school to higher education has been identified as the point at which both the largest proportion of students leave the science and technology trajectory and the exit rates of women exceed those of men by the largest margin (Xie and Shauman, 2003). At the same time, women seem less inclined than men to choose a STEM discipline when completing a non-scientific or technological track in high school. While women's participation overall in higher education has been growing around the world in the past decades, tertiary enrollment rate increases have been concentrated in fields where women's participation was already high (UNESCO, 2007). But female representation in STEM disciplines remains low, due to several factors which have a negative effect on information access, study field selection, retention, and graduation. The literature indicates that preferences, motives, values, stereotypes, and cultural norms can explain this situation.

[3] Nevertheless, "the decision to continue with S&T at a higher level of education (and to choose this as a career) is strongly influenced by experience at earlier levels of schooling, and indeed in most cases depends on achieving a certain level in mathematics and science in primary and especially secondary school". Moreover, "the percentage of girls who say that the sort of science done in schools makes them less likely to go for a job in S&T rises from 34 percent in year 7 to 83 percent in year 11" (OECD, 2008).

Ceci and Williams (2011) affirm that in the United States, “the primary factors in women’s underrepresentation [in science] are preferences and choices—both freely made and constrained. Females make this choice despite earning higher math and science grades than males throughout schooling.”[4] Students’ plans for their future education and careers are influenced by their expectations about their social roles. Anticipated family roles and responsibilities play a central part in future planning and influence individuals’ expectations. Based on a survey of 600 Swiss university students who were asked about their reasons for selecting a field of study, Suter (2006) points out that women prefer careers that do not conflict with family responsibilities and are useful in childrearing, such as education, psychology, or medicine. Therefore, it seems that women do not consider STEM fields to be family-friendly (OECD, 2008). In addition, Xie (2006) finds that it may be harder to combine family and work in some fields (e.g., those that demand many lab hours) than in other fields (e.g., social sciences).

Other authors note that women are drawn to fields that are more related to people than to numbers (OECD, 2008; Baker and Leary, 1995; Ceci and Williams, 2011). In a similar vein, Gilbert, Crettaz Roten and Alvarez (2003) highlight that in Switzerland “empirical evidence suggests that young men make their choice mostly based on career prospects, whereas women are also motivated by social and/or political commitments.” OECD (2008) states that “students who evaluate social skills and key competences as important for working in a modern economy may be discouraged from pursuing engineering studies, especially women.”

Stereotypes, social norms, and cultural practices also lead to the segregation of women into certain fields of study. Zubieta (2006) indicates that, in Latin America, stereotypes have worked as ideological and social barriers preventing females from significantly impacting these professions. In addition, Suter (2006) argues that stereotypes deter women from careers in STEM fields because many believe these fields to be more related to male than female characteristics.[5]

Family background and the absence of female role models can also influence women’s participation in STEM careers (OECD 2008; Suter, 2006; Xie, 2006). Xie (2006) argues that

[4] Carrell, Page, and West (2009) identify a set of experimental studies in which women’s career decisions are explained by ability self-perceptions, preferences, risk aversion, and expectations. Along these lines, the literature shows that girls are less likely than boys to hold positive attitudes toward math and to regard math as a subject that will be useful in their future.

[5] Correll (2001: p. 1724) studies how high school students’ perceptions of their mathematical competence influenced their decisions to pursue a quantitative career. This author found that “since males tend to overestimate their mathematical competence relative to females, males are also more likely to pursue activities leading down a path toward a career in science, math, and engineering.”

young people make career choices on the basis of adult workers' experiences. When women become successful in a field, the next generation is more likely to emulate their success. In addition, a woman's family could influence her selection of a field of study. Suter (2006) states that female students in engineering and other branches of science often have at least one parent with a profession in one of these disciplines. This clearly points to the importance of having a female role model working in a male-dominated profession or field of study.

In male-dominated fields - such as STEM ones - cultural norms are a key factor in explaining the low participation of women. NAS (2007) highlights that STEM department culture in the United States influences female recruitment because male professors may feel more comfortable working with male students and women may feel marginalized or unwelcome (unintentionally). This report also notes that in graduate school women may find a chilly climate, face harassment, and not be engaged by faculty in professional socialization. If women are having more negative experiences in graduate school than men, they may be more inclined to leave (Ferreira, 2003).

Cultural norms and stereotypes can also affect women's access to accurate information, as well as their perceptions regarding STEM careers. UNESCO (2007) states that qualified girls may not receive appropriate information on Science and Technology courses and careers and may be steered into other fields. Many girls and their advisors are influenced by stereotypes that tell them that certain jobs are for men only. Grubb (2002) argues that popular knowledge of the costs and benefits of higher education are drastically out of kilter with reality and may constitute a barrier to education. In addition, BiTC (2010) points out that despite high aspirations among ethnic minorities and women, these groups have downward misperceptions of future rewards in many of the key professions, effectively inhibiting them from choosing these careers. Women are less informed about wages for less popular disciplines. Unfortunately, they seem to be uninformed with a downward bias (Tacsir, 2014).

2.2 Career Development

The gender gap in STEM labor force participation is in most cases wider than the gender gap in educational trajectory. This evidence suggests that U.S. women face more significant barriers to becoming scientists or engineers than do men with comparable educational credentials (Xie and

Shauman, 2003). Indeed, Xie (2006) shows that eliminating gender differences in the attainment of educational credentials would only slightly narrow the gender gap in participation in STEM occupations. Hence, most of the gender gap comes from the *utilization* of the education among those who have attained it.

Female career development in these fields is characterized by vertical segregation, meaning that women are concentrated at the bottom of the hierarchy but not present in decision-making or leadership positions. In this sense, two different effects associated with the development of women's professional life have been identified: revolving doors and the glass ceiling. The former is related to the high exit rates of women who enter male-dominated fields and the latter refers to the difficulties that women face in rising to the top because of slow or blocked career progress (Suter, 2006).

After graduation, women have to overcome several barriers in order to enter and progress in their professional careers. These include biased recruitment and hiring procedures, restrictive regulations, biased promotion practices, lack of access to networks, stereotypes, work-life balance issues, and evaluation practices. All of these barriers affect women's access to STEM fields, hiring and promotion opportunities, retention, and career success (Sheridan, 1998; Corley, Bozeman, and Gaughin, 2003; Schiebinger, 2010).

2.2.1. Junior Positions

In the competition to obtain entry-level positions, women can be penalized by gender-biased recruitment and hiring procedures, as well as by restrictive regulations and norms. The ways that professionals are attracted to certain positions, how the interviews take place, and even how the evaluation results and the job offer are communicated influence women's participation (Suter, 2006). Bowles, Babcock, and Lai (2007) used experimental economics to show that gender differences in the propensity to initiate negotiations may be explained by differential treatment of men and women when they attempt to negotiate. For example, male evaluators penalized female candidates more than male candidates for initiating negotiations. Petersen, Saporta and Seidel (2000) analyzed the hiring process of a mid-sized U.S. high-technology organization, finding that gender could have a negative impact on the initial salary offered (Valian, 1999; Brown, Swinyard, and Ogle, 2003; Sturm, 2009.)

Evaluation of scores and recommendation letters also shows that male candidates are preferred over females. Numerous experiments have clearly evidenced this result. Steinpreis, Anders and Ritzke (1999), in a study involving 238 American psychologists, argues that both men and women faculty members have a significant preference for hiring a male, rating systematically male research, teaching, and service above identical record of female candidates. Trix and Pzenka (2003) analyze over 300 letters of recommendation for medical faculty at a large American medical school, finding that gender stereotyping systematically resulted in female candidates receiving less favorable recommendations than men. Schmader, Whitehead, and Wysocki (2007) perform a linguistic comparison of letters of recommendation for male and female applicants for either a chemistry or biochemistry faculty position at a large U.S. research university and find that recommenders used significantly more stand-out adjectives to describe male compared to female candidates. Letters containing more standout words also included more ability words and fewer grindstone words.

Moreover, women can be affected by restrictive regulations and norms, which can influence their access to STEM careers, by setting inappropriate physical requirements for jobs such as heavy lifting or restrictions such as working at night (UNESCO, 2007). EC (2008) points out that in Europe there are structural barriers, embedded in regulations, which have been created by still predominantly male hierarchies, and there are social assumptions concerning the role of men and women that hinder the utilization of potential.

2.2.2. Career Progression

Along with career progression, women, face still more obstacles—some new and others already described. These barriers are related mainly to networking access, male-dominated culture, stereotypes, and personal and professional life conflicts.

Networking plays an important role in career advancement in academic or scientific careers, as new job or grant opportunities are usually disseminated through networks. However, the literature indicates that women are often excluded from social networks (Mattis, 2002). A report prepared by the Massachusetts Institute of Technology (1999) points out that women systematically report being excluded from informal social gatherings and more formal events, as well as from collaborating on research or teaching. Therefore, women’s lack of involvement could lead to important information loss in terms of grant opportunities and available positions

(Suter, 2006). UNESCO (2007) reinforces this idea, pointing out that women could be excluded from networks due to cultural norms, leaving them in a disadvantaged position with respect to men in relation to information on funding opportunities. In addition, OECD (2006) finds that women who care for small children are especially excluded from networks, as distinct from men.

An overall male-dominated culture can also have an impact. It can generate an unpleasant environment for women, discouraging their participation or even supporting their exit. Fox (2005) states that women's participation, performance, and advancement are not a simple function of their individual characteristics, such as prestige of doctoral origin, training, or skills. But their participation and achievements could also reflect the features of the organizational contexts in which they work, including organizational climate and culture, work structures, evaluative practices, and reward patterns. For instance, in a survey of over 3,700 U.S. female engineers, Fouad and Singh (2011) confirm that the workplace climate and culture are one of the factors that encourage women to leave engineering. McIlwee and Robinson (1992) argue "there is a distinct, male-centered 'culture of engineering' that generates an unfavorable climate for women and thus makes their access to this profession more difficult, particularly to the most prestigious positions in research and development" (OECD, 2006). A report by UNESCO (2007) states that sexual harassment or discriminatory practices that take place in this environment affect women in the workplace and discourage them (Equal Opportunities Commission, 2004).

Other factors that can explain the difficulties for women to progress in scientific and technological careers are related to the presence of stereotypes, which affects the possibility of obtaining a better job or research funding (Suter, 2006),[6] to express their own ideas, or even to lead teams (UNESCO, 2007). Moreover, the lack of role models among the upper echelons may hinder women's career progression (Holmes and O'Connell, 2007).

Finally, conflicts between family and work life can have a strong impact on women's career development. This factor is present at all stages of the career path (OECD, 2006, 2008; UNESCO, 2007; EC, 2005). Bullers (1999) and Sax et al. (2002) show that female faculty members are less satisfied than men with the interaction between their personal and professional lives. OECD (2008) points out that women—even those who graduated from the best schools—still tend to choose professions that will allow them to control their working hours in order to be

[6] In a recent empirical study of 770 American law firms, Gorman (2005) found that hiring criteria with male gender stereotypes lead to a preference for hiring men whereas hiring criteria with female gender stereotypes lead to a preference for hiring women.

compatible with their family life. In this sense, UNESCO (2007) states that the career development of a woman may be affected by taking time out from employment when her children are young. It is then difficult to return to a position comparable to those held by others who have not taken time off and have been steadily advancing in their careers. This is especially true in the world of scientific research, where publishing is a key component of career advancement. Moreover, household responsibilities affect not only available time for employment, but also geographic and career mobility. And successful careers in STEM are often associated with the gaining of varied experience, particularly experience abroad (Wood, 2004).[7]

2.2.3. Leadership Positions

The absence of women in leadership positions is a constant in STEM fields.[8] The barriers presented in the previous section, such as promotion practices, stereotypes, and conflicts between private and public life, among others, also have an effect on reaching leadership positions. However, at this stage, another key factor is related to the way that success is evaluated.

Generally, evaluation of success, required to reach leadership positions in science, is related to productivity. Differences in productivity may partially explain the lower promotion rates of women in some areas, such as materials science, biology, and physics (Bordons and Mauleón, 2006). Many studies have shown that women tend to publish less than men in most STEM fields. This phenomenon, characterized as the "productivity puzzle" nearly three decades ago by Cole and Zuckerman (1984), remains to this day a key factor in understanding female underrepresentation in leading positions in science. Several reasons have been identified to explain their poorer performance: lack of access to information, funding, or institutional support; biased research evaluation procedures; and low recognition in the field.

With regard to funding, evidence shows that women have neither the same access to information nor receive the same support as men. For instance, according to Sedeño (2001), Ibero-American women are members of low-power committees, have fewer financial resources, less support from staff or are located in offices which are further away, do not have access to

[7] Caprile and Vallès (2010) support the finding that lack of mobility affects women's careers. In their work, several other studies related to women's mobility constraints are mentioned (e.g. Baptista, 2000; Cutileiro, 1987; Perista and Silva, 2004; and Rodrigues, 2005).

[8] The received literature highlights that women are promoted in a lower proportion (or less likely) and more slowly than men (UNESCO,2007; OECD, 2006; NAS, 2006). For instance, the NAS (2006) shows that in almost all disciplines (social sciences, biological sciences, and STEM) and ranks (assistant, associate, and full professor) in three top American universities, men are promoted more rapidly than women, taking significantly less time to become associate professors.

"beginners' networks" in order to obtain information, and do not have role models or mentors whom they can ask for advice and support. Moreover, evaluation of productivity takes into account only the number of papers published and not their impact. UNESCO (2007) states that while straight index counts generally indicate lower production rates by women, the use of a quality-weighted index that takes into account the number of times an article is cited demonstrates a higher level of scholarly production by women. According to this report, although women are as likely as men to collaborate on research projects, they tend to belong to smaller teams that publish less, so that their rate of return on collaboration is lower than for men. Research indicates that women also co-author less often than men, which is a disadvantage in ranking because single and co-authored publications are weighted equally.

Finally, EC (2005) points out that the existing systems of defining and evaluating scientific excellence are not as gender-neutral as they are claimed to be. UNESCO (2007) argues that bias occurs in the definition of scientific excellence and assessment criteria, the choice of explicit and implicit indicators to measure excellence—differing application of measurement criteria to men and women—and in the failure to integrate women into scientific networks and assessment frameworks. And empirical evidence shows that an article receives lower reviews when it is identified as written by a woman (Paludi and Bauer, 1983).

Another explanation for the low presence of women is that peers are often required to nominate a colleague to a high-level position. STEM fields are male-dominated areas, and there is a tendency to discriminate against women when considering a promotion (UNESCO, 2007).[9] Zinovyeva and Bagues (2011) support the idea, discovering that a greater participation of women on promotion committees in Spain increases women's probability of achieving full professorships.

The procedures for reaching decision-making positions could also be gender-biased. In a 1997 empirical study on postdoctoral fellowships in Sweden, Wenneras and Wold (1997) found that applications presented by men received systematically higher scores than those presented by equally productive women. In addition, based on Handelsman et al. (2004) and Symonds et al. (2006), UNESCO (2007) points out that in order to obtain a promotion, women usually need to achieve higher scores than men in all of the relevant criteria. Thus, there is a general tendency to

[9] Based on Ding, Murray, and Stuart (2006); Stuart and Ding (2006); Murray and Graham (2007), Whittington (2008) highlights that women faculty do not sit on scientific advisory boards at the same rate as men scientists, and at the highest level of commercial involvement, they make up miniscule percentages of company founders.

see women as less competent than men and their accomplishments as less worthy and significant (NAS, 2007).

3. Policies to Promote the Participation of Women

Around the world, governments, universities, and international organizations have been designing and implementing policies to overcome the barriers mentioned in Section 2 and to promote women's participation in scientific and technological fields. While many of these policies are targeted to solve problems related to a particular career stage, several of those actions affect more than one stage at a time.[10]

In Europe, most of the countries have undertaken efforts to incorporate gender equality in STEM.[11] In fact, the majority of EU member countries have implemented policies related to women and science, committing to gender mainstreaming, creating National Committees on Women and Science, publishing sex-disaggregated statistics, and promoting gender studies and research. However, the implementation of more specific policies varies widely across the region (see Table 2).[12]

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[10] The Gendered Innovation of Science, Medicine and Engineering Project of Stanford University has identified governments, academic institutions, industry, and private sector corporations' initiatives that aim to reduce gender bias and structural obstacles. All of these policies and programs are available at http://genderedinnovations.stanford.edu/fix-the-institutions/institutional-transformation.html. In addition, the genSET project of the European Commission provides several resources on women's participation in science regarding science knowledge-making; research process; recruitment and retention; assessment of women's work; and science excellence value system, available at http://www.genderinscience.org/resources.html. Castaño, Müller, Gonzalez and Palmén (2010) presents a meta-analysis of gender in science research across Europe, with the objective of reviewing policies toward gender equality in STEM covering the period 1980 to 2008. Huyer (2004) lists and reviews some of the most significant initiatives, such as: the South Africa Reference Group on Women in Science and Technology; the Helsinki Group of the European Union; the Gender, Higher Education, and S&E Research Reforms in Sweden; the U.S. Equal Opportunities in Science and Engineering Act, and the Regional Chairs for Women in Science and Engineering of Canada.

[11] Müller , Castaño, Gonzalez and Palmén (2011) state that the role of women in science emerged as a major policy concern in Europe in the late 1990s. Specifically, the aim of promoting gender equality in science was considered "as an essential condition for building the European Research Area"(p. 302).

[12] Several documents presents the current gender policy mainstreaming as well as programs executed in Europe such as Rees (2002); EC (2008a and 2008b); OECD (2008), UNESCO (2007), and Sretenova (2010).

Table 2. Gender Equality Policies in EU Member Countries

	EU-Member States (25)																								
Equality Measures in Science	BE	CY	CZ	DK	DE	EE	EL	ES	FR	IE	IT	LV	LT	LU	HU	MT	NL	AT	PL	PT	SI	SK	FI	SE	UK
Equal treatment legislation (general)	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Commitment to gender mainstreaming	X	X	X	X	X		X	X	X	X	X		X	X			X	X	X	X	X		X	X	X
National Committee on Women & Science	X	X	X	xx	X	X	xx	X	X	X	X		X		X	X		X	X	X	X	X	X	X	
Women & Science Unit in Research Ministry					X		X5	X	X		X							X	X						X
Publication of Sex-disaggregated Statistics	X	X	X	X	X	X	X	X	X	X		X	X	xx	X	X	X	X	X	X	X	X	X	X	X3
Development of Gender equality indicators	X4			X	X		X		X	X	X	X			X	X		X		X	X		X	X	X
Gender balance targets: public committees	X2			X	X		X		X	X													X	X	X
Gender balance targets on university ctees		X		X	X				X								X4	X					X	X	X4
Gender Equality Plans in Univ.& Research I.	X4			X	X				X	X	X			xx			X4	X					X	X	
Gender² Studies & Research at Universities	X	X	X	X	X	X	X	X	X	X	X	X	X	xx	X	X	X	X	X	X	X	X	X	X	X
Programmes on W&S, special funding available					X		X		X	xx	X	xx	xx			X	X	X			X				X
Nationwide Centres on Women & Science			X		X																				X

***Source:** Information provided by the members of the Helsinki group & EOWIN, Summer 2004, DG RTD, UNIT C4* xx = in preparation

²)or women studies/research X1= only BE French-spreaking X2= only BE Dutch-speaking X3= not for industrial R&D

x = yes blanc cell = no X4= set by certain universities X5= person only responsible for W&S

Notes: BE=Belgium, CY=Cyprus, CZ=Czech Republic, DK=Denmark, DE=Germany, EE=Estonia, EL=Greece, ES=Spain, FR=France, IE=Ireland, IT=Italy, LV=Latvia, LT=Lithuania, LU=Luxemburg, HU=Hungary, MT=Malta, NL=The Netherlands, AT=Austria, PL=Poland, PT=Portugal, SI=Slovenia, SK=Slovakia, SK=Slovakia, FI=Finland, SE=Sweden and UK=United Kingdom.
Source: EC (2005).

A first group of programs centers on increasing women's participation in tertiary science education, including mentoring programs which link Ph.D. students, post-docs and senior members (Norway and Germany), and motivational meetings for female school leavers. Some policies attempt to make scientific fields more appealing for women. These policies aim to overcome gender differences in teaching and enhance the image of STEM careers (OECD, 2008). Box 1 presents some of these experiences in the United States and EU. The general result of this type of programs is that they encourage women in their career aspirations. Women gain self-confidence, network with colleagues in similar situations and acquire a deeper understanding of university and research organizations and structures (Müller et al, 2011).

Box 1. S&T Women's Support Programs

Women Give New Impetus to Technology (Germany)
The main objective of this non-profit organization ("Competence Center Technology-Diversity-Equal Chances") is to help shape Germany's path toward becoming an information- and knowledge-based society. To this end, it develops and carries out a wide range of initiatives and projects that exploit the potential of women and men in all spheres of society and work. The organization groups its activities into three areas of expertise: digital integration, focusing on equal access to changed lifestyles and labor markets; training, further education and careers, concentrating on gender-oriented vocational and life planning and the transition from school to work; and higher education, science and research, to intensify efforts to promote talented young women in relevant academic subjects and research. The goals of the organization's measures and projects are to strengthen media literacy and increase Internet use; to foster new ways of thinking about career orientation and life planning; and to promote equal opportunity and excellence in higher education, science, and research.

The Great sEXPERIMENT (Belgium)
The Great sExperiment is an interactive exhibition about the talents of women and men. Through more than 40 interactive exhibits, visitors participate in an experiment to find out what women can do better than men or what men can do better than women. People of all ages can discover their own and each other's talents and skills. The exhibition lets women and men discover that science and technology are not exclusively "men's work."

Athena Project (UK)
Hosted by the Royal Society of London, the aim of this project is to promote the careers of women in science and technology at all UK universities and research institutions and to increase the number of women in high-level positions. In collaboration with UK universities, the project developed the "Athena Guide to Good Practice," which offers approaches for making S&T departments more hospitable to female faculty members. These strategies include developing mentoring and networking programs and instituting good management practices.

The ETHNIC Project (EU)
The European Commission's ETHNIC (Raising Awareness of Science and Technology among Ethnic Minorities) project ran from 2003 to 2005. The main objective was to raise awareness of science and technology among ethnic minorities, emphasizing engineering, IT, and biotechnology. The target beneficiaries of the 80 million euro project were young people from ethnic minorities, parents, the science and technology community, and the media. The project was based on a multi-level program of activities, encompassing after-school sessions, information days, seminars, consultative panels, and exhibitions. Project partners came from Austria, the UK, Slovenia, the Czech Republic, Hungary, and Italy. The Slovenian and British partners are continuing with the development of tools, primarily training guides.

SciTech (Sweden)*
Commissioned by the Swedish government, the National Agency for Higher Education created SciTech, a five-year program to enhance public interest in science and technology especially among young adults. Another objective of the program is to stimulate the development of new methods of education in these

fields. In order to offer a wide variety of courses and programs, such as IT courses on the popular subject "computer knowledge," various types of institutions work together. Besides these courses, the program offers career counseling for careers in science and technology and individually tailored study plans. Courses, which prepare students for higher education, are also organized. A unique characteristic of the initiative is its focus on gender equality. Special university classes for women have been arranged within the framework of the SciTech program. This may have contributed to the recent increase in the number of girls studying science and technology in Sweden. The Swedish government provides funding of approximately 400 million euro annually to the program.

Increasing the Participation and Advancement of Women in Academic Science and Careers - Advance Program (USA)

The goal of the National Science Foundation's (NSF) ADVANCE program is to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse science and engineering workforce. ADVANCE encourages institutions of higher education and the broader science, technology, engineering, and mathematics (STEM) community, including professional societies and other STEM-related not-for-profit organizations, to address various aspects of STEM academic culture and institutional structure that may differentially affect women faculty and academic administrators. This multi-component program provides three types of awards: institutional transformation, leadership, and fellows. The Institutional Transformation (IT) grants are designed to systemically transform institutional practices and climate at universities and colleges in order to recruit, retain, and promote women in academic science and engineering careers. This work seeks to engage all stakeholders, within an institution and beyond, in the achievement of these goals. In particular, the program aims at facilitating the transition of girls interested in STEM disciplines from secondary school to universities, through admittance campaigns focused on girls and scholarship programs. Since 2001, the NSF has invested over $130 million to support ADVANCE projects at more than 100 institutions of higher education and STEM-related not-for-profit organizations.

Source: Box extracted from OECD, 2008, p. 107; SciTech Case extracted from Box 3.3. Encouraging general S&T literacy, OECD, 2008, p. 97; Athena Project Case taken from "Women for Science", Inter-Academy Council, June 2006; Advance Program Case elaborated by the authors.

A second line of policies aims at promoting women's careers and increasing their scientific productivity. Interventions include policies related to access to research funding and information, adapting advertising language to make it more woman-friendly, offering funds for women in research (Germany), awarding additional points in the evaluation to projects that include gender balance (Spain and Greece), providing economic incentives to gender-balanced research departments, and facilitating networking among women.[13]

[13] Among others, the European Platform of Women Scientists (EPWS), Training Seminars for Women Scientists (ENCOUWOMSCI), Network of Women Scientists (SET-ROUTES), European Network of Mentoring Programs for Women in Academia and Research (EUMENT NET), and the Association for Women in Science (AWIS), are opportunities for women to network. Mentoring programs constitute one of the most widespread and popular measures. Müller et al.(2011) indicates, for example, that in Germany there are approximately 75 mentoring programs across universities and faculties of applied sciences in the country, while in Switzerland 39 different mentoring projects were funded in the period 2000 to 2007.

In order to provide hiring incentives, several countries have been implementing policies, such as institutional awards for gender issues (Switzerland and Norway) or, in an attempt to balance family and work responsibilities, they have supported subsidized childcare and maternal leave or more flexible work schedules (Slovenia, Finland, Sweden, Belgium, and Norway). Mentoring programs, search committees to identify qualified female candidates for senior positions (Germany and Norway), regulation and legislation, and targets and quotas are instruments and programs that have been implemented in recent decades. Box 2 presents some of these initiatives.

Box 2. International Initiatives Promoting Women's Careers in S&T

Countries have been implementing policies, programs, and strategies to encourage and support women's participation in science and technology fields, especially in those which they have been historically underrepresented, such as engineering and physics. Following are some of these initiatives:

Norwegian University of Science and Technology (NTNU)
This university has implemented women's mentoring programs in order to promote gender equality and organizational development. The main purpose of this program is to facilitate a constructive dialogue between the mentor and the mentee. In addition, the NTNU also provides a "start package" to women who are in male-dominated departments to support their research activities.

The European Platform of Women Scientists (EPWS)
EPWS is an international non-profit organization that represents the needs, concerns, interests, and aspirations of more than 12,000 women scientists in Europe and beyond. Since its inception in 2005, more than 100 networks of women scientists and organizations promoting women in science from 40 countries have joined the Platform, working for the promotion of equal opportunity in the research fields of all scientific disciplines and aiming to give women scientists a voice in European research policy.

Netherlands Aspasia Program
The Aspasia program was launched in 1999 by the Ministry of Education, Culture and Science, the Association of Universities in the Netherlands and the Netherlands Organization for Scientific Research (NWO) and has been designed to alleviate the under-representation of women in the upper echelons of academia. The aim of Aspasia is to encourage the promotion of female academics to senior lecturer (or professorial) level. Aspasia is linked to two of the NWO's competitive grant schemes: Vidi (for experienced researchers) and Vici (for researchers of professorial quality). Aspasia provides grants to help more female scientists progress to associate and full professorships. The program has boosted the proportion of women among associate proportion from 9 percent in 1999 to 14 in 2003 (Visser et al, 2003). At the same time, the grantees felt that the program encouraged them to develop their own research and view it as a recognition for their own efforts and performances (Bosch and Potting, 2001; Donselaar, 2006)

G&D-Rockefeller Fellowship Program
The Rockefeller Foundation in 2005, joined by the Syngenta Foundation for Sustainable Agriculture in 2006, funded the CGIAR Gender & Diversity Program (G&D) to design and implement a pilot fellowship program to enhance the careers of women crop scientists in East Africa, in particular in Kenya, Tanzania

and Uganda. As a core concept, it organized formal mentoring by a senior scientist for each fellow throughout her fellowship as well as leadership and negotiations training and access to electronic networking with women scientists around the world.

Borlaug Fellowship Program

The Norman E Borlaug International Agricultural Science and Technology Fellows' Program launched a Women in Science (WIS) component in 2005. This program also was based on a form of mentorship, but its approach emphasized short-term scientific training and research collaboration. Young women scientists working in agriculture in West African institutions were supported to spend four to six weeks at highly regarded US universities to initiate collaborative research on a topic of mutual interest with successful senior scientists who served as their short-term mentors. The Borlaug Women in Science Fellowship Program is funded by the US Agency for International Development (USAID) and managed by the US Department of Agriculture (USDA).

Source: Authors' elaboration

It is important to know how effective these policies have been in promoting gender equality.[14] To this end, several of them, including the ADVANCE Fellows Program, the Aspasia Program of the Netherlands, and the G&D-Rockfeller and the Borlaug Fellowship Programs, were evaluated to determine whether they have had a positive impact on women's careers (Chu Clevel, Cosentino de Cohen, Tsui and Dterding, 2006; Van Donselaar; 2006; Ward, 2006). In general, these initiatives were found successful although they presented some issues at the design and implementation stages. Results of the evaluation of the ADVANCE Program are summarized in Box 3, while those of the G&D-Rockfeller and the Borlaug Fellowship Programs are presented in Box 4.

[14] EC (2008b) warns that correlating key national policies targeting women and science with national statistical profiles presents two real difficulties. First, establishing clear-cut relations between certain policy measures and the overall representation of women is problematic (p.14). In addition to the lack of time series data, specific measures are always part of a wider social context that makes hard to attribute change to one source alone. Second, some of the policies showed no statistically significant correlation, requiring a more thorough examination of measures and initiatives at sub-national levels (p. 38). Müller et al (2011, p. 300) states, when analyzing policies in Europe, is that "except in isolated cases, the theoretical foundations for operationalizing gender equality and carrying out sound evaluations were seldom explicitly acknowledged or mapped out […] Most research therefore identifies measures and factors that are beneficial for the advancement of women in science but fall short of integrating these findings into a sound theoretical model for social change."

Box 3. Evaluation of ADVANCE Fellows Program

In 2004, the National Science Foundation performed an interim assessment of the ADVANCE Fellows Program. This evaluation found that 34 percent of awardees vs. 24 percent of declinees had acquired a tenure-track position since the time of application; two-thirds of the non-tenure-track awardees indicated that ADVANCE research support had facilitated their research productivity and better positioned them to secure a tenure-track position; 57 percent of declinees reported essentially no change in professional circumstances; and 20 percent of those declinees said that their circumstances had worsened.

The benefits of the program include: preventing women from leaving academia, time and resources to conduct research, buyout of teaching loads, the ability to build independent research programs; better positioning to look for permanent jobs; use of the award as a negotiating chip in interviews; opportunity to retool, build new skills, and become more marketable; recognition, especially from external sources; leverage for bringing in additional funding; serving as a solution to balancing dual academic careers; and academic reentry, retention, and career development.

Source: Extracted from Ward (2006).

Summarizing the literature, Müller et al (2011) indicates that scholarships, grants and stipends are an invaluable instrument or reaching the next qualification stage, but they fail to guarantee integration into the scientific community or to impact the organizational level of research institutes or universities. In fact, providing women with temporary positions do not often lead them to fixed positions, making preferable the financial support through the creation of concrete positions.

Box 4. G&D-Rockefeller and Borlaug Women in Science Fellowship Programs Evaluation

The Gender and Diversity (G&D)-Rockefeller Fellowship Program to Enhance the Careers of East African Women Crop Scientists, based in Nairobi, Kenya, and the Women in Science Component of the U. S. Department of Agriculture's (USDA) Norman E. Borlaug International Agricultural Science and Technology Fellows Program, based in Washington DC, were launched in 2005 to boost the careers of African women in agricultural research. The purpose of the evaluation was to take a closer look at their synergies, the sustainability of the effects the programs have had on the fellows, dissect reasons for success or failure in achieving expected results, and propose what should be done in the future.

The evaluation used a mixed-methods approach to enable triangulation of information from different sources and methods (as well as the evaluator's expertise) to ensure credible evidence and detect biases or manipulation of facts or perceptions. The methods included a document review, one-on-one interviews, surveys, and an assessment of fellows' research-related outputs as well as "impact stories."

The evaluation found that the two "proof of concept" programs are both success stories, although both faced challenges in design and execution. They both gave the participating women the skills, exposure, and opportunities needed to assess their strengths and weaknesses and to explore how to use these to their advantage both professionally and in enhancing their scientific profiles. The fellowships thus provided avenues for African women to envision crafting their futures as leaders in the scientific arena.

A number of reasons were identified for the relative success of both programs. The holistic designs were based on evidence from earlier G&D experiences and other Borlaug programs. In both programs, the components effectively reinforced and built on one another. One of the key strengths was that both programs followed adaptive management approaches, helping them to evolve as lessons were learned. This was done with greater efficiency in the G&D Program, which had a monitoring and accountability system that exceeded those of most pilot programs. Implementation was done well, in particular in the G&D Program, whose attentive and efficient management team ensured continuous assessment of progress and individual support when problems were encountered. This type of approach is cost-intensive yet value-adding, complicating any cost-benefit calculation, as the nurturing and supportive approach helped maximize the potential benefits of the program.

The G&D Program was somewhat more successful than the Borlaug Program, primarily due to two design elements and one implementation factor. In terms of the design elements, the G&D Program i) focused on an extended period of mentoring by a senior scientist, often a role model working in a similar environment and adept at encouraging and building those soft skills necessary to navigate organizational dynamics where women are still a minority, and ii) provided support for fellows to attend international science conferences to present their research, boosting their confidence and increasing their visibility. The implementation factor refers to the highly committed G&D management team that worked consistently and responsively to support its fellows as individuals and as a network.

Source: Ofir (2008).

4. Final Comments

The incomplete exploitation of women's potential in STEM areas constitutes an important lost opportunity for society. However, women face multiple barriers that prevent their recruitment, retention, and promotion along the entire STEM career path.

Depending on career stage, a number of obstacles have been identified in the literature, mostly with respect to developed countries. Personal preferences, stereotypes, lack of role models, and cultural norms impact women's choices in higher education, while gender-biased recruitment, hiring and evaluation processes, restrictive regulations and norms, exclusion from networks, male-dominated culture, and work-family conflicts have significant direct negative effects on various aspects of women's career development. Moreover, women face several additional barriers that affect their performance and consequently their career progression, such as lack of access to information, funding or institutional support, biased research evaluation procedures, and low recognition in the field.

Several countries have recognized the significance of these barriers and have implemented policy instruments to overcome them and encourage gender parity in science. Despite these efforts, differences in participation, productivity, and progression up the academic and technological ladders persist. This is even truer in Latin America, where policies aimed at promoting women's presence in science are sporadic and based on scant information that is fragmented among different agencies and bodies. Indeed, with respect to advanced education, most countries collect data on gender only at the aggregate level, and breakdowns by field of science are rare. As for indicators on scientific careers, information is usually potentially available at scientific councils but is neither collected nor disseminated.

Finally, gender-disaggregated lists of science and technology products - publications and patents, for example - are seldom published. Having complete and comparable information on the real dimension and features of the gender gap in science and technology careers in the region is key to understanding its root causes and proposing effective policies. A preliminary research effort is needed, consisting of the production and dissemination of gender-disaggregated statistics and studies on the possible peculiarities of the gender breakdown in science in Latin America and the Caribbean and a rigorous evaluation of the impacts of various policy instruments designed to address them.

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