Volume-3, Issue-8, August Special Issue-2014 • ISSN No 2277 - 8160

Research Paper | Social Sciences

Womenin Scienceand Technology

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ABSTRACT

Skillgapsareakeyconstrainttoinnovation,hinderingproductivity growthand economicdevelopment. Inparticular,shortagesinthesupplyoftrained professionalsindisciplinesrelatedtoScience,Technology,Engineering, and Mathematics (STEM)mayweakentheinnovationpotentialofasociety.Awide gender gaphaspersistedovertheyearsatalllevelsofSTEMdisciplines throughouttheworld.Althoughtheparticipationofwomeninhighereducation hasincreased,theyarestillunderrepresented.LatinAmericaisnoexception.Theuntappedpotentialoffullytrainedandcredentialedwomenrepresents an importantlostopportunitynotonlyforwomenthemselvesbutalsoforsocietyas awhole.Althoughthereisgrowingrecognitionoftheimportance oftheissuein developing countries, LatinAmericafacesalackofinformationthatprevents researchersfromdeepeningtheunderstanding ofthisphenomenonand policymakersfromdesigningeffectiveinterventions. Thisnoteaimstocontribute totheacademicand policydebateintheregionbyreviewingthemainfactorsput forwardintheliteraturetoexplaingenderinequalitiesinrecruitment, retention, andpromotioninSTEMdisciplines andbyprovidingevidence ofthescopeand resultsof policiesdirectedtoobtainabettergenderbalanceinthesector.

KEYWORDS : Science,technology,occupation, academicpromotion.

1.Introduction

Skillgapsareakeyconstrainttoinnovation,hinderingproductivity growthandeconomic development.Inparticular,shortagesinthesupplyoftrainedprofessionalsindisciplinesrelated toscience,technology,engineering,andmathematics (STEM)mayweakentheinnovation potentialofasociety.Empirical studiesshowthatcountrieswithahigherproportionof engineeringgraduatestendtogrowfasterthancountrieswithahigherproportionofgraduatesin otherdisciplines. Inaddition,futuretechnicalchangeis likelytobelinkedtoabilitiesandtasksrelatedtoSTEMdisciplines.

Awidegender gaphaspersistedovertheyearsatalllevelsofSTEMdisciplines throughout theworld.Althoughwomenhavemadeimportantadvancesintheirparticipationin highereducation,theyarestillunderrepresentedin thesefields.Thisproblemis moreacuteatthe senior-mostlevelsofacademicandprofessionalhierarchies.Genderequalityinscience, technology,andinnovationisnotsimplyamatteroffairness. Amoreequitablegenderbalanceisbelievedtoenhancetherecruitmentofthemosttalented,irrespectiveofgender,tappingapartiallyunexploitedresource. A more inclusive workforce isassumedtobemoreinnovative andproductive thanonewhichis lesso(NationalAcademyofSciences,2006).Havingscientistsandengineers withdiverse backgrounds,interests,andculturesassuresbetterscientificandtechnologicalresultsandthe bestuseofthoseresults.Genderequalityisseenasawaytopromotescientificand technologicalexcellencerather than justimprovingopportunitiesfor

women.Theuntappedpotentialoffullytrainedandcredentialedwomenwhomightbeinterested inSTEMbutchoosenottopursuedegreesinthesefieldsorwhodecidetochangecareers becauseofobstacles,realorperceived,representsanimportantlostopportunitynotonlyfor 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.

Althoughthereisgrowingrecognitionoftheimportance oftheissueindeveloping countries,mostoftheliteratureongenderinequalitiesinSTEMandthepoliciesdesignedtorectifythemrelatetotheUnitedStatesandEurope. Notonlyarewomeninlatin America underrepresentedinSTEMfields;theyarealsounder-measured,andthelackofinformationhas preventedresearchersfromdeepeningunderstanding ofthereasonsforthisgap. Ithasalso preventedLatinAmericanpolicymakersfromdesigningeffectiveinterventions.

Thispaperaimstocontributetotheacademicandpolicydebatein LatinAmericaon genderinSTEM.Section2reviewsthemainhypothesesandfactorsputforwardintheliterature toexplaininequalities inrecruitment, retention,andpromotionupthecareerladder.Section3 presentsthemostimportant policiesputinplaceworldwidetocontribute toabettergender balanceinSTEMfields.Section4 concludeswithfinalcomments.

2. BarrierstotheParticipationofWomeninSTEM

Afullunderstanding ofthefactorsconstrainingwomen'scareerpathsinSTEMhasoftenbeen hampered bythepersistence ofseveralmythsandclichés.Table1presentssomeofthese commonly heldbeliefsandcontraststhemwithexistingevidence.

2.1 HigherEducation

Althoughthefirstinteractionwithscience andmathematicsoccursinelementaryandsecondary education,tertiary[3]educationisthecriticalstepinwhichstudentsdecidetheirfuturecareers. The transition fromhighschool tohigher educationhasbeenidentifiedasthepoint atwhichboththe largestproportion ofstudentsleavethescienceandtechnologytrajectoryandtheexitratesof womenexceedthoseofmenbythelargestmargin.Atthesametime, womenseemlessinclinedthanmentochooseaSTEMdisciplinewhencompletinganon-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.

CeciandWilliams (2011)affirmthatintheUnitedStates,"theprimaryfactorsin women'sunderrepresentation[inscience]arepreferencesandchoices—bothfreelymadeand constrained.Femalesmakethischoicedespiteearninghighermathandsciencegradesthan males throughoutschooling."Students' plansfor their future education and

careers are influencedbytheirexpectations abouttheirsocialroles.Anticipated familyrolesand responsibilitiesplayacentralpartinfutureplanningandinfluenceindividuals' expectations. Basedonasurveyof600Swissuniversity studentswhowereaskedabouttheirreasonsfor selecting afieldofstudy,Suterpointsoutthatwomenprefercareersthatdonotconflict withfamilyresponsibilitiesandareusefulinchildrearing, suchaseducation,psychology,or medicine.Therefore,itseemsthatwomendonotconsiderSTEMfieldstobe

family-friendly. In addition, findsthatitmaybehardertocombinefamilyandwork in somefields(e.g.,thosethatdemandmanylabhours) thaninotherfields(e.g.,socialsciences).

Otherauthorsnotethatwomenaredrawntofieldsthataremorerelatedtopeople thanto numbers.Inasimilarvein, Gilbert,CrettazRotenandAlvarezhighlightthatinSwitzerland"empirical evidence suggeststhatyoungmenmaketheirchoicemostlybasedoncareerprospects,whereaswomen arealsomotivatedbysocialand/orpoliticalcommitments." OECDstatesthat"students whoevaluatesocialskillsandkeycompetences asimportantforworkinginamoderneconomy maybediscouragedfrompursuingengineeringstudies,especiallywomen."

Stereotypes, socialnorms,andculturalpracticesalsoleadtothesegregationofwomen intocertainfieldsofstudy.Zubietindicatesthat,inLatinAmerica,stereotypeshave workedasideological andsocialbarrierspreventingfemalesfromsignificantlyimpactingthese professions. Inaddition,Suterarguesthatstereotypesdeterwomenfromcareersin STEM fieldsbecausemanybelievethesefieldstobemorerelatedtomalethanfemalecharacteristics.[5] Familybackgroundandtheabsenceoffemalerolemodelscanalsoinfluencewomen'sparticipationinSTEMcareers. Xiearguesthatyoungpeoplemakecareerchoicesonthebasisofadultworkers'experiences.Whenwomen become successfulinafield,thenextgeneration ismorelikelytoemulate theirsuccess.In addition,awoman'sfamilycouldinfluence herselectionofafieldofstudy.Suterstates thatfemalestudentsinengineering andotherbranchesofscienceoftenhaveatleastoneparent withaprofessioninoneofthesedisciplines.Thisclearlypointstotheimportance ofhavinga femalerolemodelworkinginamale-dominatedprofessionor fieldof study.

Inmale-dominated fields-suchasSTEMones-culturalnormsareakeyfactorin explainingthe lowparticipationof women.NAShighlightsthatSTEM department cultureintheUnitedStatesinfluencesfemalerecruitmentbecausemaleprofessorsmayfeel morecomfortableworkingwithmalestudentsandwomenmayfeelmarginalizedorunwelcome (unintentionally).Thisreportalso notesthatingraduateschoolwomenmayfindachillyclimate, faceharassment,andnotbeengagedbyfacultyinprofessionalsocialization.Ifwomenare havingmorenegativeexperiences ingraduateschoolthanmen,theymaybemoreinclinedto leave. Culturalnormsandstereotypescanalsoaffectwomen'saccesstoaccurateinformation, aswellastheirperceptions regardingSTEMcareers.UNESCOstatesthatqualifiedgirlsmaynotreceiveappropriateinformationonScienceandTechnologycoursesandcareersand maybesteeredintootherfields.Manygirlsandtheiradvisorsareinfluencedbystereotypesthat tellthemthatcertain jobsareformenonly.Grubbargues thatpopular knowledge ofthe costsandbenefits ofhighereducationaredrasticallyoutofkilterwithrealityandmayconstitute abarriertoeducation. Inaddition,BiTCpointsoutthatdespitehighaspirationsamong ethnicminoritiesandwomen,thesegroupshavedownwardmisperceptions offuturerewardsin manyofthekeyprofessions,effectivelyinhibitingthemfromchoosingthesecareers.Women arelessinformedaboutwages forlesspopulardisciplines. Unfortunately, theyseemtobe uninformedwithadownwardbias.

2.2 CareerDevelopment

ThegendergapinSTEMlaborforceparticipation isinmostcaseswiderthanthegendergapin educational trajectory.Thisevidencesuggeststhat U.S.womenfacemoresignificantbarriersto becomingscientistsorengineersthandomenwithcomparableeducationalcredentials. Indeed,Xie(2006)showsthateliminating genderdifferences intheattainment ofeducational credentialswouldonlyslightlynarrowthegendergapinparticipationinSTEM occupations. Hence,mostofthegendergapcomesfromthe*utilization*oftheeducationamong thosewho haveattainedit.

Femalecareerdevelopment inthesefieldsischaracterizedbyverticalsegregation, meaningthatwomenareconcentratedatthebottomofthehierarchybutnotpresentindecision- makingorleadershippositions.Inthissense,twodifferent effectsassociated withthe developmentofwomen'sprofessionallifehavebeenidentified:revolvingdoorsandtheglass ceiling.Theformerisrelatedtothehighexitratesofwomenwhoentermale-dominated fields andthelatterreferstothedifficulties thatwomenfaceinrisingtothetopbecauseofslowor blockedcareerprogress.

Aftergraduation,womenhavetoovercomeseveralbarriersinordertoenterandprogress intheirprofessionalcareers.Theseincludebiasedrecruitment andhiringprocedures,restrictive regulations, biased promotion practices, lack of access to networks, stereotypes, work-life balance issues,andevaluation practices.Allofthesebarriersaffectwomen'saccesstoSTEM fields,hiringandpromotionopportunities,retention,andcareersuccess.

3. PoliciestoPromotetheParticipationofWomen

Around theworld, governments, universities, and international organizations have been designingandimplementingpoliciestoovercomethebarriersmentionedinSection2andto promotewomen'sparticipationinscientificandtechnological fields.Whilemanyofthese policiesaretargetedtosolveproblemsrelatedtoaparticularcareerstage,severalofthose actionsaffectmorethanonestageatatime.

InEurope,mostofthecountrieshaveundertakeneffortstoincorporategenderequalityin STEM.Infact,themajorityofEUmembercountrieshaveimplementedpoliciesrelatedto womenandscience,committingtogendermainstreaming,creatingNationalCommittees on WomenandScience,publishingsex-disaggregated statistics,andpromotinggenderstudiesand research.However,theimplementationofmorespecificpoliciesvarieswidelyacrosstheregionAfirstgroupofprogramscenteronincreasingwomen'sparticipationintiaryscience education,includingmentoringprograms whichlinkPh.D.students,post-docsandsenior members(NorwayandGermany),andmotivational meetingsforfemaleschoolleavers.Some policiesattempt tomakescientific fieldsmoreappealing forwomen. Thesepoliciesaimto overcomegenderdifferencesinteachingandenhancetheimageofSTEMcareer.

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 EXPERIMENT (Belgium):

The Great Experiment 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 men-

toring 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 thesefields.In ordertooffera widevarietyofcoursesandprograms,suchas IT coursesonthepopularsubject "computerknowledge,"varioustypesofinstitutionsworktogether.Besidesthesecourses,theprogram offers career counseling for careers in science and technology and individually tailored study plans. Courses,whichpreparestudentsforhighereducation,arealsoorganized. Auniquecharacteristicofthe initiativeisitsfocusongenderequality.Specialuniversityclassesforwomenhavebeenarrangedwithin theframeworkof theSciTechprogram.Thismayhavecontributedto therecentincreasein thenumberof girlsstudyingscienceandtechnologyin Sweden. The Swedishgovernmentprovidesfundingof approximately400millioneuroannuallytotheprogram.

Increasing the Participation and Advancement of Women in Academic Science and Careers - AdvanceProgram(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 contributingto thedevelopmentofa morediversescienceandengineeringworkforce. ADVANCE encouragesinstitutionsof highereducationandthe broaderscience,technology,engineering,and mathematics(STEM)community,includingprofessionalsocietiesandotherSTEM-relatednot-for-profit organizations,toaddressvariousaspectsofSTEMacademicculture andinstitutionalstructurethatmay differentiallyaffectwomenfacultyandacademicadministrators.Thismulti-componentprogramprovides three typesof awards: institutional transformation, leadership, and fellows. The Institutional Transformation(IT)grantsare designedto systemicallytransforminstitutionalpracticesandclimateat universities and colleges in order to recruit, retain, and promote women in academic science and engineeringcareers.Thisworkseekstoengageallstakeholders,withinaninstitutionandbeyond,inthe achievementofthesegoals. Inparticular,theprogramaimsatfacilitatingthetransitionofgirlsinterested inSTEMdisciplinesfromsecondary schooltouniversities, throughadmittance campaigns focusedon girls and scholarship programs. Since 2001, the NSF has invested over $130 million to support ADVANCEprojectsat morethan100institutionsofhighereducationandSTEM-relatednot-for-profit organizations.

2. InternationalInitiativesPromotingWomen'sCareersinS&T
Countrieshavebeenimplementingpolicies,programs,andstrategiestoencourageandsupportwomen's participationin scienceandtechnologyfields,especiallyin thosewhichtheyhavebeenhistorically underrepresented,suchasengineeringandphysics.Followingaresomeofthese initiatives:

NorwegianUniversityofScienceandTechnology(NTNU)
Thisuniversityhasimplementedwomen'smentoringprogramsinordertopromotegenderequalityand organizational development. Themainpurpose ofthisprogram istofacilitate aconstructive dialogue betweenthementorandthementee.Inaddition,theNTNUalsoprovidesa"startpackage"towomen whoareinmale-dominateddepartmentstosupporttheirresearchactivities.

TheEuropeanPlatformofWomenScientists(EPWS)
EPWS is an international non-profit organization that represents the needs, concerns, interests, and aspirations ofmorethan12,000womenscientists inEuropeandbeyond.Sinceitsinception in2005, morethan100networksof womenscientistsandorganizationspromotingwomeninsciencefrom40 countrieshavejoinedthePlatform,workingforthepromotionofequalopportunityintheresearchfields ofallscientificdisciplinesandaimingtogivewomenscientistsavoiceinEuropeanresearchpolicy.

NetherlandsAspasiaProgram
The Aspasiaprogramwaslaunchedin1999bytheMinistryof Education,CultureandScience,the AssociationofUniversitiesintheNetherlandsandtheNetherlandsOrganizationforScientificResearch (NWO) andhas beendesignedto alleviatethe under-representationof womenin the upperechelonsof academia.TheaimofAspasiaistoencouragethepromotionoffemaleacademicstoseniorlecturer(or professorial) level. Aspasia is linked to two of the NWO's competitive grant schemes: Vidi(for experiencedresearchers)andVici(forresearchersofprofessorialquality).Aspasiaprovidesgrantstohelp more femalescientists progress to associate and full professorships. The programhas boosted the proportion ofwomenamongassociateproportion from9percentin1999to14in2003. At the same time, the grantees felt that the program encouraged them to develop their own researchandviewit asa recognitionfortheirowneffortsandperformances.

G&D-RockefellerFellowshipProgram
TheRockefellerFoundationin2005,joinedbytheSyngentaFoundationforSustainableAgriculturein 2006,fundedthe CGIARGender&DiversityProgram(G&D)todesignandimplementa pilotfellowship programtoenhancethecareersofwomencropscientistsinEastAfrica,inparticularinKenya,Tanzania and Uganda. Asacore concept, itorganized formal mentoring byasenior scientist foreach fellow throughout her fellowship as well as leadership and negotiations training and access to electronic networkingwithwomenscientistsaroundtheworld.

BorlaugFellowshipProgram
TheNormanEBorlaugInternationalAgriculturalScienceandTechnologyFellows'Programlaunchеda WomeninScience(WIS)componentin2005.Thisprogramalsowasbasedonaformofmentorship,but its approachemphasized short-term scientific training and research collaboration. Young women scientistsworkinginagricultureinWestAfricaninstitutionsweresupportedtospendfourtosixweeksat highly regarded US universities to initiate collaborative research on a topic of mutual interest with successfulseniorscientistswhoservedas theirshort-termmentors.The BorlaugWomenin Science FellowshipProgramisfundedbytheUSAgencyforInternationalDevelopment(USAID) andmanaged bytheUSDepartmentofAgriculture(USDA).

3. Evaluationof ADVANCEFellowsProgram
In2004,theNationalScienceFoundationperformedan interimassessmentof theADVANCEFellows Program. Thisevaluationfoundthat34percentofawardeesvs.24percentofdeclineeshadacquireda tenure-trackpositionsincethetimeofapplication;two-thirdsofthenon-tenure-trackawardeesindicated thatADVANCEresearchsupporthadfacilitatedtheirresearchproductivityandbetterpositionedthemto securea tenure-trackposition;57percentofdeclineesreportedessentiallyno changeinprofessional circumstances;and20percentofthosedeclineessaidthattheircircumstanceshadworsened.

Thebenefitsoftheprograminclude:preventingwomenfromleavingacademia,timeandresourcesto conductresearch,buyoutof teachingloads,the abilityto buildindependentresearchprograms;better positioningtolookforpermanentjobs;useoftheawardasanegotiatingchipininterviews;opportunity to retool,buildnewskills,andbecomemoremarketable;recognition,especiallyfromexternalsources; leverageforbringinginadditionalfunding;servingasasolutiontobalancingdualacademiccareers;and academicreentry,retention,andcareerdevelopment.

4. FinalComments
Theincomplete exploitationofwomen'spotentialinSTEMareasconstitutesanimportantlost opportunity forsociety.However,womenfacemultiplebarriersthatpreventtheirrecruitment, retention,andpromotion-

alongtheentireSTEMcareerpath.

Dependingoncareerstage,anumberofobstacleshavebeenidentified intheliterature, mostly withrespect to developedcountries.Personal preferences,stereotypes,lack of role models,andculturalnormsimpact-women'schoicesinhighereducation,whilegender-biased recruitment, hiringandevaluationprocesses,restrictiveregulationsandnorms,-exclusionfrom networks,male-dominated culture,andwork-familyconflictshavesignificantdirectnegative effectsonvariousaspect-sofwomen'scareerdevelopment. Moreover,womenfaceseveral additionalbarriersthataffecttheirperformanceandconsequentlytheir-careerprogression,such aslackofaccesstoinformation,fundingorinstitutional support,biasedresearchevaluation procedures,andlowrecognitioninthefield.

Several countries haverecognized the significance of these barriers and have implemented policyinstrumentstoovercomethemandencouragegenderparityinscience. Despitetheseefforts,differencesinparticipation,productivity, andprogressionuptheacademic andtechnological ladderspersist. ThisiseventruerinLatinAmerica,wherepoliciesaimedat promoting women'spresence insciencearesporadic andbasedonscantinformationthatis fragmentedamongdifferentagenciesandbodies.Indeed,withrespecttoadvancededucation, mostcountriescollectdataongenderonlyattheaggregatelevel,andbreakdownsbyfieldof science arerare. As forindicators on scientific careers, information is usually potentially availableatscientificcouncilsbutisneithercollectednor disseminated.

Finally,gender-disaggregatedlistsofscienceandtechnologyproducts-publicationsand patents,forexample-areseldompublished. Havingcompleteandcomparableinformationon thereal dimensionandfeaturesofthegendergapinscienceandtechnologycareersintheregion iskeytounderstandingitsrootcausesandproposingeffectivepolicies. Apreliminary research effort is needed, consisting of the production and dissemination of gender-disaggregated statisticsandstudiesonthepossiblepeculiarities ofthegenderbreakdowninscienceinLatin America and the Caribbean and a rigorous evaluation of the impacts of various policy instrumentsdesignedtoaddressthem.

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