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Effective Policies for Supporting Education and Employment of Women in Science and Technology

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ABSTRACT

Human resources have played a crucial role in the Republic of Korea's economic growth. Men have taken up most of the economically active population, however, and this male dominance has been more pronounced in science and technology (S&T). The Republic of Korea is plagued by the world's lowest birthrate, a rapidly aging society, and falling enrollment in science and engineering (S&E). All of these factors draw attention to the power and potential of the nation's woman workforce. In 2002, the Korean Government legislated to strengthen the capacity of women in science and technology and to improve the retention of women scientists and engineers. Based on this act, a five-year basic plan for fostering and utilizing women in science and technology was started in 2004. This paper introduces a statistical overview of Korean women in science and technology, key policies to support their education and employment, the outcome of each policy, and suggestions for improving policy effectiveness.

I. STATISTICAL OVERVIEW

Statistics on Korean education published by the Korean Educational Development Institute (KEDI) in 2008 show that 46.7 per cent of all middle school students (2,038,611) were girls and 28.2 per cent of high school girls (409,990) were studying science subjects, which are required to major in science or engineering at university.

* The views expressed in this paper are those of the author and do not necessarily represent those of the United Nations.

Girls represented about 35 per cent of high school students studying science subjects.

Tables 1 through 4 show the status of students by S&E degree programme, the status of graduates with S&E degrees, and new and total employment in research and development (R&D) sectors in 2008. Figure 1 illustrates the representative ratios in bold in Tables 1-4. The ratio changes of women in science and engineering in academia are plotted in Figure 2 from 2005 to 2008. In the category of pure natural science shown in Figure 2, living science, which is an area where women are main players, is excluded.

Table 1. *No. and ratio of female students by S&E degree programme (2008)*
Unit: No. of persons, per cent

Program / Field	Associate		Bachelor		Master		Doctorate		Total	
	Total	Female (ratio)	Total	Female (ratio)	Total	Female (ratio)	Total	Female (ratio)	Total	Female (ratio)
Science	32,862	17,855 (54.3)	178,105	94,032 (52.8)	15,165	7,212 (47.6)	6,716	2,659 (39.6)	232,848	121,758 (52.3)
Engineering	120,566	19,000 (15.8)	357,962	64,504 (18.0)	31,982	4,467 (14.0)	9,417	966 (10.3)	519,927	88,937 (17.1)
Total	153,428	36,855 (24.0)	536,067	158,536 (29.6)	47,147	11,679 (24.8)	16,133	3,625 (22.5)	752,775	210,695 (28.0)

Note: Associate refers to a degree offered by a two or three-year college and bachelor by a four-year university.
Source: Raw data of the Statistics on Korean Education, KEDI (2008)

Table 2. *No. of women graduates with S&E degrees (2008)*
Unit: No. of persons, per cent

Degree/ Field	Associate			Bachelor			Master			Doctorate			Total		
	Sci	Eng	total	Sci	Eng	total	Sci	Eng	total	Sci	Eng	total	Sci	Eng	Total
Total	15,259	52,252	67,511	38,375	78,684	117,059	5,829	12,539	18,368	1,592	2,078	3,670	61,055	145,553	206,608
Female (ratio)	8,432 (55.3)	7,947 (15.2)	16,379 (24.3)	20,661 (53.8)	1,847 (16.3)	33,508 (28.6)	2,712 (46.5)	1,767 (14.1)	4,479 (24.4)	572 (35.9)	190 (9.1)	762 (20.8)	32,377 (53.0)	22,751 (15.6)	55,128 (26.7)

Note: Associate refers to a degree offered by a two or three-year college and bachelor by a four-year university.
Source: Raw data of the Statistics on Korean Education, KEDI (2008)

Table 3. *Hiring of S&T women personnel in R&D sectors (2008)*
Unit: No. of institutes, No. of persons, per cent

Status / Sector (No. surveyed)	Regular		Non-regular		Total	
	Total	Female (ratio)	Total	Female (ratio)	Total	Female (ratio)
University (277)	1,340	307 (22.9)	2,734	605 (22.1)	4,074	912 (22.4)
Public Research Institute(172)	688	148 (21.5)	2,628	1,025 (39.0)	3,316	1,173 (35.4)
Private Research Institute(1,603)	8,710	1,366 (15.7)	99	29 (29.3)	8,809	1,395 (15.8)

Total (2,052)	10,738	1,821 (17.0)	5,461	1,659 (30.4)	16,199	3,480 (21.5)

Source: Report of the 2009 Investigative Research on the Actual Status of Utilizing of Women in S&T, NIS WIST, MEST (2010)

Table 4. *Total employment of S&T women personnel in R&D sectors (2008)*
Unit: No. of institutes, No. of persons, per cent

Sector (No. surveyed) \ Status	Regular		Non-regular		Total	
	Total	Female (ratio)	Total	Female (ratio)	Total	Female (ratio)
University (277)	24,967	2,939 (11.8)	53,439	16,217 (30.3)	78,406	19,156 (24.4)
Public Research Institute (172)	22,094	2,658 (12.0)	7,412	3,183 (42.9)	29,506	5,841 (19.8)
Private Research Institute (1,603)	81,844	7,846 (9.6)	545	223 (40.9)	82,389	8,069 (9.8)
Total (2,052)	128,905	13,443 (10.4)	61,396	19,623 (32.0)	190,301	33,066 (17.4)

Source: Report of the 2009 Investigative Research on the Actual Status of Utilizing of Women in S&T, NIS WIST, MEST (2010)

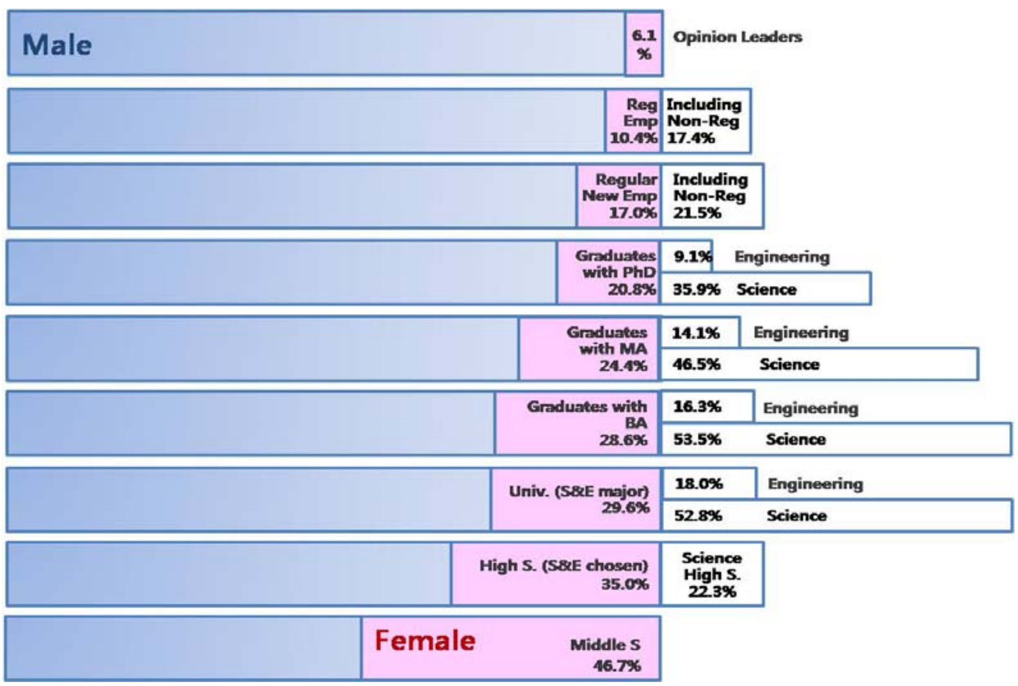

Fig.1 *Diagram of sex ratio in S&T from high school to opinion leading stage (2008)*

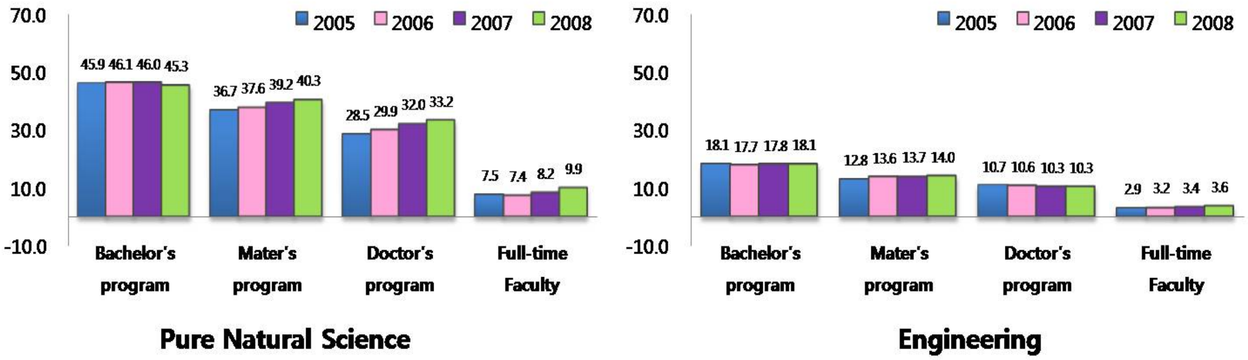

Fig.2 *Ratio changes of women in science and engineering at academia (2005-08)*

Table 5 shows the status of economic activity participation in 2008. The economic activity participation rate (64.4 per cent) for women who majored in science and engineering was slightly higher than the average (64 per cent) for women in all fields and much lower than the rate (91 per cent) for men who majored in science and engineering. Figure 3 shows that the economic activity participation rates for married women were much lower than those for unmarried women in all fields. The activity rates for married men, however, were higher than those for unmarried men.

Table 5. *Economic activity participation (2008)*
Unit: No. of persons, per cent

Sex/Field \ Personnel			Economically active population			Economically inactive population	Economic activity participation rate	Un-employment rate
			Employed	Un-employed	Total			
Female		Science	473,548	15,915	489,463	305,787	61.5	3.3
		Engineering	299,083	12,231	311,314	137,212	69.4	3.9
	S& E		772,631	28,146	800,777	442,999	64.4	3.5
	Medical Science & Pharmacy		289,868	4,313	294,181	96,122	75.4	1.5
	Other fields		2,122,113	71,438	489463	1,310,868	62.6	3.3
	Total		3,184,612	103,897	3,288,509	1,849,989	64.0	3.2
Male		Science	742,941	22,685	765,626	91,795	89.3	3.0
		Engineering	2,093,248	62,746	2,155,994	196,144	91.7	2.9
	S& E		2,836,189	85,431	2,921,620	287,939	91.0	2.9
	Medical Science & Pharmacy		148,571	4,329	152,900	14,236	91.5	2.8
	Other fields		2,507,071	74,108	489463	429,833	85.7	2.9
	Total		5,491,831	163,868	5,655,699	732,008	88.5	2.9

Note: Economically active population (EAP) = No. of the employed and the unemployed seeking jobs aged 15 or over
Economic activity participation rate = EAP / (Population of age ≥ 15) x 100
Unemployment rate = No. of unemployed aged 15 or over / EAP x 100
(Numbers are drawn by counting the number of those holding an associate degree or higher, excluding those enrolled in a degree programme or on leave of absence)
Source: Raw data from Economically Active Population Survey, Statistics Korea (2008)

Fig.3 *Economic activity participation rates of (un)married by major (2008)*

The key issues to be inferred from the statistical data are: (i) The ratio of girls to all students in "science high school" was 22.3 per cent in 2008, which gradually decreased from 31.4 per cent in 2004. (ii) The ratio of girls to all high school students was 35 per cent in 2008, down from 36.1 per cent in 2005. In 2008, 28.2 per cent of high school girls took science and engineering courses, falling from 29.2 per cent in 2005. (iii) The percentages of women students in natural science were much higher than those in engineering. Women represented about 45 per cent of university students pursuing Bachelor's degrees in pure natural science (excluding living science) and about 18 per cent in engineering. (iv) The proportions of women in master's programmes of science and engineering, in doctorate programme of science and in full-time faculty of science and engineering are in increasing trend in recent years. (v) Of new recruits in regular S&T positions in 2008, 17 per cent were women, down from 18.4 per cent in 2007 but higher than 15.9 per cent in 2004. (vi) Women researchers in regular S&T positions have represented about 10 per cent of the S&T workforce since 2004, but those in non-regular positions have comprised about 32 per cent. In other words, about 60 per cent of women R&D employees in science and technology hold non-regular jobs. (vii) The fact that 6.1 per cent of S&T opinion leaders are women indicates the typical leaky pipeline of women's careers in science and technology. (viii) The economic activity participation rate for married women who majored in medical science and pharmacy was much lower than those for unmarried women, implying that balancing work and family for such women in professional fields remains a challenge.

II. KEY POLICIES AND OUTCOME

A strengths, weaknesses, opportunities and threats (SWOT) analysis based on the statistical figures of the education and employment of women in science and technology and recent characteristics of Korean society can be summarized as follows.

Strengths:

- High academic achievement of female students
- Meets the average of women earning bachelor's degrees in S&E in Organization for Economic Cooperation and Development (OECD) countries
- Increasing ratio of women in S&E master's programmes

Weaknesses:

- Decreasing ratios of female students at high schools especially in "science" high schools and in S&E bachelor's programmes

- Low ratio of women earning S&E doctorates
- Low rate of economic activity participation by women
- High ratio of temporary workers among women S&T employees

Opportunities:

- Inadequate human resources in S&T
- Need for development of source technology and diversity
- Shortage of economically active human resources due to low birth rate and rapidly aging society

Threats:

- Male-oriented education in S&E
- Lack of infrastructure for work-family balance
- Criticism of reverse gender discrimination for affirmative action programmes promoting women in S&E

Based on the Act on Fostering and Supporting Women Scientists and Technicians that took effect in 2002, the Korean Government has established the Basic Plans for Fostering and Supporting Women in Science and Technology every five years since 2004 and implemented policies to promote women in science and technology. The major policies mainly commissioned by the Ministry of Education, Science and Technology (MEST) and the outcome of each policy will be introduced.

1) 3W Projects to encourage young girls for majoring in S&E

The 3W projects are WISE, WIE, and WATCH21. The WISE (Women Into Science and Engineering) began as a pilot programme in 2001 to encourage young girls to major in science and engineering. The main strategy is online mentoring. Based on the Act, WISE has developed an S&E friendly programme, an S&E experience programme, and an S&E career development programme since 2002. Successful online as well as offline mentoring raised the number of active mentor-mentee pairs to 1,300 in 2007 with the aim of 2,000 by 2013. About 60 per cent of mentors are from academia, about 50 per cent of mentees are college students, and another 30 per cent of mentees are high school girls. The number of young girls participating in WISE was about 35,000 in 2007 and the goal is 50,000 by 2013. As shown in the statistical overview, the ratios of female students to total students in S&E courses at high school and S&E majors at university have slightly decreased despite WISE.

To promote women engineers and technicians, the WIE (Women in Engineering) project was launched in 2006. The Korean Government has designated five universities with engineering colleges as leading centers of engineering education for women. The mission of the leading universities is to build a gender-recognized educational system, develop field adaptation programmes, and encourage employment of women graduates. As a result, 52 new courses have been developed, 53 were improved over three years, and the employment rate of women graduates increased from 66.1 per cent in 2006 to 76.8 per cent in 2008 on average. More than 80 per cent of the programme’s participants, who were female/male students, male faculty members, and enterprises, expressed satisfaction. The transfer rate of female students from an engineering college to another such as that for humanities or social science significantly decreased at the leading universities.

The WATCH21 (Women’s Academy for Technology Changer in the 21st Century) programme, started in 2004, is a research and education programme for providing high school girls with experience at engineering research laboratories. A team consists of four to five high school girls, two female engineering majors, and a female graduate student of engineering. The team is guided by a high school science teacher, an engineering professor, and a woman professional in a technology-related industry. Between 2004 and 2009, 315 teams with 2,238 female students participated in this R&E programme and more than 90 per cent of them said they were satisfied.

The 3W projects receive a subsidy of US$3M from the Government each year and are believed to have helped raise the ratio of women with S&E doctorates from 16.3 per cent in 2004 to 20.8 per cent in 2008. The number of women graduates with S&E doctorates was 762 in 2008, and the plan is to raise that number to 1,000 by 2013.

2) Recruitment Target System for women scientists and engineers

The Recruitment Target System (RTS) for women scientists and engineers was adopted in 2001 by the National Science and Technology Council (NSTC) under a presidential decree and applied to 25 government-funded S&T institutes. Since 2003, just after the Act on Fostering and Supporting Women Scientists and Technicians took effect, all 98 national and governmental S&T institutes have become targets of this policy. The RTS is under the supervision of the Ministry of Education, Science and Technology, and the aim is to increase the average rate of women recruits by the 98 institutes to 30 per cent by 2013, when the second Basic Plans for Fostering and Supporting Women in Science and Technology will end. The 98 institutes must report their hiring data to the NSTC every year. The rate of women recruits increased from 18.2 per cent in 2003 to 26.6 per cent in 2009. The 25 government-funded institutes that set their own targets performed well by raising their average rate from 10.4 per cent in 2003 to 19.7 per cent in 2009. Since 2009, the Minister Awards of the Ministry of Education, Science and Technology are given to outstanding institutes.

The RTS was also applied to 23 national and public universities. Between 2003 and 2005, the former Ministry of Education and Human Resources Development allocated 200 new faculty positions for women only in all fields. This policy resulted in a significant increase in the female faculty rate from 9.2 per cent (5.2 per cent in S&E) in 2003 to 10.7 per cent (6.5 per cent in S&E) in 2005. Since 2005, the rate of female recruits to new faculty has gradually increased to 12.2 per cent (7.4 per cent in S&E). Despite an increase in the number of women with doctorates, the failure to allocate new faculty positions to women has resulted in a slower increase in the rate.

3) Promotion Target System for women scientists and engineers

Since 2007, the Promotion Target System (PTS) has been recommended to 25 government-funded S&T institutes with the goal of having women comprise 30 per cent of those promoted. The percentage of women promoted is not that discouraging if the percentage of female candidates for promotions is considered (See Table 6). The lack of women scientist and engineer candidates is expected to ease in the coming decades considering that 20.6 per cent of senior researchers are women who will be candidates for director sooner or later. Yet women scientists and engineers say the PTS must be applied to all 98 national and governmental S&T institutes if policies for supporting women in S&T are to be effective.

Table 6. *Percentage of women candidates and promotions*
Unit: per cent

Type/Year	2007		2008		2009	
	Candidates	Promoted	Candidates	Promoted	Candidates	Promoted
To Director	6.7	8.4	7.5	7.3	5.1	4.0
To Senior Manager	20.6	15.2	21.3	22.9	21.0	17.9
Total	11.7	11.5	12.7	14.4	9.9	9.5

4) Designation of officer in charge of women scientists and engineers

To improve the working conditions and environment for women scientists and engineers, governmental organizations with 30 or more women scientists and engineers as regular employees are required to designate a senior officer in charge of women employees. The target organizations are government-funded or invested national/public institutes and universities. A combined 23 institutes and 10 universities are target organizations.

The officer monitors, consults, diagnoses, and reports everything on promoting women employees. He or she is also educated and trained twice a year to maximize the effectiveness of the mission.

Most of such officers are men, however. Moreover, supervising women employees is not the only duty for the officers. For successful performance of the officer's mission, diagnosis indices for gender equality have been developed to let the officer diagnose his or her organization. Four of the indices are equal employment, equal opportunity, family friendliness, and affirmative action measures. Each category has four to five sub-indices. The qualities of equal employment and family friendliness at institutes are higher than at universities, while institutes are scored lower in equal opportunity and affirmative action. The higher the scores of the quality and implementation of the measures, the more gender equality there is. The scores of such measures slightly increase every year at most target organizations.

5) Exclusive research funds for women scientists or engineers

To encourage women scientists and engineers to stay on as researchers and to foster outstanding female talents in S&T, an R&D budget has been exclusively allocated for women scientists since 2000. The budget began at US$2.5M in 2000 and reached US$15.7M in 2010. On average, about 30 per cent of applicants receive funds, though the overall budget has significantly increased. The ratio of women project managers more than doubled from 6 per cent in 2003 to 14 per cent in 2009. A Point Award System, which gives extra points to women researchers or those returning from maternity leave, and a quota system in which 14 per cent of project managers must be women were adopted for use in general research funds.

6) Childcare center at Daedeok Research Complex

The childcare center (nursery school) at Daedeok Research Complex in Daejeon was built for women scientists and engineers not by the Ministry of Gender Equality but by the former Ministry of Science and Technology. The complex has 20 per cent of the country's women scientists and engineers. The nursery school can accommodate 300 babies and toddlers between the ages of 15 and 60 months. It is open from 7:30 a.m. to 10:30 p.m. Women scientists and engineers from 37 institutes inside the complex who use this nursery school have expressed a high level of satisfaction. The nursery school gets subsidies from institutes having employees using the nursery school.

7) Institute for Supporting Women in Science and Technology

Article 14 of the Act on Fostering and Supporting Women Scientists and Technicians defines the foundation, duty, and management of a working center, namely the Institute for Supporting Women in Science and Technology (ISWIST). The center is tasked with carrying out research in policy development; educating, training, and consulting with women in S&T; providing information on employment; and supporting organizations of women scientists and engineers. The Republic of Korea has one national institute in Seoul (NIS-WIST) and one each in Gwangju (GJIS-WIST), Busan (BIS-WIST), Daejeon (DCIS-WIST) and Daegu (DGIS-WIST) that provide nationwide coverage. NIS-WIST is responsible for the planning and steering of policy initiatives. About US$2M in government funds is allocated to these action centers each year.

ISWIST's mission is to foster women professionals in science and technology from the start of their employment to their becoming leaders in the S&T workplace. The most meaningful project is an annual investigation of the actual status of women in S&T. The report is the country's unique survey on gender recognition in S&T and provides a statistical database for policy development. The report is approved as a national statistic by Statistics Korea. Through this investigation, the matter of women employees in the R&D sector taking mainly temporary positions was first raised and is now well known to policymakers and the public.

ISWIST is offering various training and supporting programmes to individuals. These include job training as a professional science communicator and lab manager, communication skills, S&T management, leadership training, and development of research ability. About 1,000 women science communicators have been trained and about 70 per cent of them work as afterschool science teachers, science writers, and screenwriters, producers, and actresses of science plays. About 200 women lab managers have been trained for supporting research laboratories mainly at universities. About 70 per cent of them work at university research laboratories nationwide. About 10,000 women scientists and engineers have participated in the training programmes since 2005.

Non-governmental organizations (NGO) of women scientists and engineers have received financial support for national or international activities in their social and academic networking. The Association of Korean Women Scientists & Engineers (KWSE), which is the first NGO for women scientists and engineers in the Republic of Korea, organized a successful international conference initiated to launch INWES-ASIA. INWES stands for International Network of Women Engineers and Scientists. A KWSE member will serve as the next president of INWES.

The WIST-FIT (Women in S&T - Friendly Institutional Transformation) project, benchmarked from the ADVANCE programme of the United States of America's National Science Foundation, was launched in 2004 to support S&T organizations willing to promote women employees and develop a work environment conducive to family life. Six national and four private universities and 14 public R&D institutes have participated in this project. Kyungpook National University has seen the most outstanding result under this programme and has been named the Best Gender Equality University by the Ministry of Education, Science and Technology. Not only that, the ratio of women out of the university's faculty increased from 10 per cent to 12 per cent. In addition, 19 per cent of chairpersons and 22 per cent of committee members were women though women comprise just 12 per cent of the school's faculty. The institute with the best outcome under the programme has been the Agency for Defense Development (ADD), where 17 per cent of new employees in 2008 were women, a remarkable figure considering that women comprised just 4 per cent of new hires in 2005. The agency also appointed its first woman executive, authorized a Women's Development Committee, and opened nurseries in every building.

III. SUGGESTIONS

The following proposals for effective policies and programmes supporting education and employment of women in science and technology in the Republic of Korea are based on my experience and analysis.

Online-offline mentoring programme
Young girls and even S&E majors in university sorely need women scientists or engineers as mentors and role models. Mentoring programmes are known to benefit both mentor and mentee. This system is highly recommended in all stages of a woman's life.

WIE project: leading university of engineering education for women students
The underrepresentation of women in engineering is remarkable in the Republic of Korea despite advances in gender equality in education. The main barrier is the perceptions of parents, teachers, and engineering professors. This project has developed not only programmes for aspiring women engineers but also those for engineering professors, who are in a sector dominated by men. Given the Republic of Korea's need for more engineers, this project is expected to greatly contribute to fostering women engineers.

Recruitment Target System for women scientists and engineers
Despite cries of reverse gender discrimination against men, the Recruitment Target System for women scientists and engineers (or women faculty) is necessary for a time. The policy's outcome has proven satisfactory as shown in the above section; however, to ensure the best efficiency, the Recruitment Target System, Employment Target

System, and Promotion Target System should be run concurrently.

Exclusive research funds for women scientists and engineers
This policy is especially encouraging for young women scientists and engineers who experience maternity leave or childrearing. Balancing family and research remains a huge obstacle to the success of women scientists and engineers. Research funds that are exclusively for women scientists or engineers can help them continue their research, overcome breaks in their research careers, and help them develop into leading scientists.

Childcare center at Research Complex
The former Ministry of Science and Technology had the great idea to build a nursery school running for 15 hours, though less than 10 per cent of children on average use the night-care programme after 7:30 p.m. A strong need exists to build new nursery schools for women scientists and engineers.

Institute for Supporting Women in Science and Technology
One of the most effective policies is the legal establishment of the action center for monitoring, steering, planning and implementing governmental policies and programmes for women in science and technology. ISWIST has focused on maximizing employment of women in science and technology in parallel with the 3W projects, which have focused on education of girls to major in S&E and build their careers in science and technology. The Korean government will soon merge the 3W projects into ISWIST so that diverse and custom-made programmes can be provided systematically and efficiently to young girls, female students majoring in S&E, women scientists and engineers, and even women leaders in science and technology. The consolidated ISWIST will be launched in January 2011 with an annual budget of US$5M.

From the mid 1990s, a series of policies to provide equal opportunities for women in the workplace were enacted. They emphasized the importance of "gender mainstreaming" as a key aspect of national policy strategy. When the recruitment target system for women scientists and engineers was announced by the Minister of Science and Technology in 2001, however, the official homepage of the Ministry of Science and Technology was once paralyzed because of disputes and objections made by men against reverse gender discrimination. Despite governmental efforts, the OECD's Reviews of Innovation Policy in the Republic of Korea still recommends that the Republic of Korea encourage more women to pursue science and engineering careers (OECD, 2009). It is more discouraging that the country's gender gap index is 115th among 134 countries according to the Global Gender Gap Report 2009 of the World Economic Forum (WEF). Data cited in the report showed that the Republic of Korea's female-to-male ratios (1.00 = equality) to be 0.71 in labour force participation; 0.67 in enrollment in tertiary education; 0.66 in professional and technical workers; 0.52 in estimated earned income; 0.16 in parliament; 0.10 in legislators, senior officials, and managers; and 0.05 in ministerial positions.

The most effective policies cited above are affirmative action for women scientists and engineers. Governmental policy must not stop at declaration, however. Strict policy enforcement, requirement of qualitative and quantitative outcomes, and incentives to encourage best practices are essential to maximize the effects of affirmative action.

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