

A Study of the Role of Female Workforce in Information and Communication Technology Sector

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Abstract. This study has the primary goal of verifying the legitimacy of policies that support the continuous participation of female workers by quantitatively confirming their role in Korea's ICT(Information and Communication Technology) sector. In addition, a way to maximize the role of women in this field was sought. To achieve this goal, the following procedures were analyzed. First, through prior research, it was confirmed that the role of women is not receiving attention in Korea, which is called an advanced country in the ICT field. Moreover, various policies to overcome this phenomenon were reviewed. Based on this review, this study analyzed the performance of women workers in the ICT industry through quantitative data. First, the case where the representative of the company is a man and the case where the representative is a woman were compared and analyzed. Furthermore, performance was evaluated based on the gender ratio of workers. As a result, it was confirmed that companies with a higher woman ratio than the average recorded high financial performance. Based on these results, it was possible to reconfirm the feasibility of policies to expand the role and proportion of women in the ICT sector, and it was confirmed that a study on specific implementation plans was needed. Secondary data given by Korean government agencies were employed for the quantitative analysis portion of the study, and SPSS 21.0 was used.

Keywords: 4th industrial revolution, ICT manpower, female workforce, ICT industry.

1. Introduction

No one would dispute that Korea's ICT industry has been world-class for the past 20 years. However, the proportion of female workers who participated was very low. In particular, the proportion of women's workforce participation in the areas emphasized in the era of the fourth industrial revolution, such as games, digital contents, and software development is the lowest level in the OECD. Table 1 shows the participation rate of women in economic activities in major OECD countries by year. From 2011 to 2020, it can be seen that the ratio of Korea is lower than the OECD average as well as Japan and the United States. In addition, in the ICT field survey conducted by a Korean government agency in 2018, it was confirmed that 25.9% of the workers in the software field were female.

Table 1: Comparison of female labor force participation rates by major countries (%).

Year	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Korea	59.1	60.0	59.4	59.0	58.3	57.8	57.1	55.6	55.2	54.90
Japan	72.5	72.6	71.3	69.4	68.1	66.7	66.0	65.0	63.4	63.00
USA	67.8	68.9	68.2	67.9	67.3	66.9	67.1	67.2	67.6	67.80
OECD Average	63.8	65.0	64.4	64.0	63.5	63.0	62.7	62.5	62.2	61.70

* Source: <https://stats.oecd.org> > LFS by sex and age

Various labor unions have been established in the ICT sector in recent years, and the work environment and atmosphere have greatly improved. However, until about 10 years ago, Korean ICT companies had taken for granted that the intensity of labor was strong and that they had to work irregularly. As a consequence, they had amassed a workforce that could commit themselves to work at all times. It can be inferred that the backwardness of the work method, which is excessively immersed according to the project deadline, created a male-centered industry and an environment in which it is challenging for women to engage.

However, recently, as the establishment of labor unions in ICT companies has become common and work methods have been improved, this negative atmosphere is dramatically improving. The ICT industry still has a bright prospects and needs further expansion and development than in the past. Therefore, there is a serious labor shortage, and methods for increasing women's participation are being studied naturally. The organizational culture and working conditions in ICT-related industries are also improving, and this development is seen as a chance to actively encourage the influx of talented female workers. This perception of the current situation does not appear only in recent studies; there have also been numerous analytical activities and policy proposals in the past. However, most of the studies focused on suggesting directions such as creating a social atmosphere, building infrastructure, and strengthening women's re-education of career breaks (Seo et al., 2020; Seok 2019).

The purpose of this study is to analyze the results of past research to confirm the flow of change and to specifically verify the change in the role of women in the ICT field through data analysis. In addition, based on these results, we would like to present the directions of applicable policies.

In order to achieve this research purpose, the research questions were specified as follows. First, does the high participation rate of female workers in the ICT sector have a positive effect on the financial performance of companies or the process of producing efficient results? Second, does the policy direction that pursues the influx of female workers in the ICT sector help companies?

2. Literature Reviews

First, the preceding studies related to the employment of female workers in the ICT field are as follows. A representative research direction is to increase the employment rate of female ICT workers. The “A Study on Strategies to Raise Female Employment in the ICT Industry” of the Ministry of Science, ICT and Future Planning (Information and Communication Policy Research Institute) comprehensively investigated the employment problem of women by looking at employment in the ICT industry, one of Korea's main industries. It was determined that the ICT industry is mainly composed of wage workers, and the proportion of regular workers exceeds 80% to create quality jobs. Therefore, the expansion of the advancement of the female workforce resolves the economic imbalance between men and women and improves the competitiveness of the ICT industry. It was also said to be an essential task. The main findings and implications are as follows. First, it may be mentioned that although the percentage of employed women and their quantitative employment are both increasing, they are still reportedly at a lower level than in OECD member countries. In addition, a similar level was shown until the twenties but declined mainly in the thirties, whose careers were cut off due to reasons such as housework and child-rearing, and the employment rate gap widened as the higher education level went. It was found that women had a relatively high proportion of temporary workers, and the wage level was found to be less than 70% of that of men. Although the overall employment situation is improving compared to the past, it was still showing poor indicators at the international level, and problems such as employment instability, wage level, and career interruption were identified in terms of employment quality. In addition, the results of the research intensively analyzing the ICT industry are as follows. First, it was found that the proportion of female workers in the publishing, video, broadcasting and communication and information service industries was lower than that of other industries. Second, in the ICT manufacturing industry, the proportion of women was higher than that of men. Third, in the software-related industry, the proportion of female workers was found to be lower than that of other ICT industries. In conclusion, women's employment in the ICT sector has a very low proportion in terms of quantity, even compared to the international level. Women's

employment in the ICT industry is mainly concentrated in the ICT manufacturing industry, and most of them have a high proportion of assembly and simple labor jobs. It was found to be particularly low in the software industry, and it was estimated that women avoided entry due to a lot of work, frequent overtime, and a male-centered culture (Ministry of Science, ICT and Future Planning (Korea) 2014).

Based on these findings, the policy directions derived to solve the problem of women's employment in the ICT industry are as follows. First, since the influx of women into related majors is low, career education and experience opportunities for various occupations in the ICT field are expanded to support competent female talents to advance into ICT sales. In particular, it suggested the direction of fostering convergence talent by reinforcing SW education for logical problem-solving ability. Second, the government should actively step forward to improve the corporate environment in the ICT field and promote active policies to resolve the gender imbalance. Hence, he pointed out that it is necessary to seek to improve the competitiveness of the ICT industry itself by solving structural problems such as subcontracting the ICT industry. Third, it was stated that different measures should be taken to prevent working mothers from leaving the job. These measures ranged from indirect measures like fostering a social environment to direct policies for a family-friendly ICT female workforce. Fourth, it was suggested that support for women who have experienced career disconnection to return to work and reemployment should be strengthened. In particular, in the ICT field, considering that reemployment is difficult due to rapidly changing technologies, it is necessary to provide various mentoring, career development programs, and employment-related support.

Woo SH (2014) suggested a solution in a similar direction. The solutions to the women's employment problem in the ICT field presented in this study are solving the problem of work-family compatibility, building a family-friendly social environment, building social infrastructure and supporting legal systems, solving the problem of career disconnection, and organizing and supporting female enterprise clusters. First, she began by outlining the shortcomings of fragmentary approaches to the compatibility of work and family, such as simple economic compensation or the growth of childcare facilities, and stressed the urgency of fostering such an environment through altering social culture. Second, the establishment of a family-friendly social environment emphasized the introduction of gender equality and family-friendly systems in preparation for the generalization of dual-income households. Third, she said that companies should break through conservative practices in order to improve Korean-style glass ceilings, and that the government should actively come up with policies. Fourth, it is necessary to actively pursue policies desired by women with career breaks such as the time selective system, flexible work system, and leave of absence system. Fifth, revitalize the convergent

industry through the establishment of a platform for women's business support, industry-academia-research networking, etc. (Woo 2014).

In addition, the study of Song JH (2014) and Lee BH & Song EJ (2014), which emphasized the role of women in the ICT field, was carried out at a time when the keyword 'creative economy' was gaining attention in Korea was examined. The two studies are comparable in that they both underlined the necessity for an institutional foundation to preserve the distinctive leadership qualities of women, such as compassion, tolerance, delicacy, and consideration, and to minimize career interruptions in the employment of women (Song 2014; Lee et al., 2014).

The second direction of research is on topics related to women's ICT capabilities. According to a study by Choi YJ, Chung HS, Ban GW, and Kim SM (2016), it was found that, among OECD countries, the competencies of employed women were rarely lower than those of non-employed women. In terms of competency, it means that the women's workforce is being deployed inefficiently. In particular, Korean women's ICT level is not only at the bottom of the world, but the gap with men is also larger than in other competence areas. Based on this analysis, the following policy suggestions were presented. First, in order to prevent the departure of high-capacity women, it was necessary to continuously strengthen the family balance policy to maintain women's careers. It also argued that learning support for incumbent women should be reinforced, and in particular, it should be actively supported for the capacity building of women in managerial positions. Above all, he emphasized that it is necessary to strengthen the ICT-related competencies, which are essential competencies in the era of the 4th industrial revolution (Choi et al., 2016).

In Song MI's study (2019), data that can be compared to Korean women's ICT capabilities with other countries around the world are presented. Looking at the proportion of science and technology-related majors, the proportion of natural sciences, engineering, and ICT in Korea was close to 30%, but the proportion of women was only 7.9%. In the ICT competency used in the workplace, women in most countries were found to be superior to men, while women in Korea and Japan scored lower than men. It can be seen that Korean women have a low proportion of working in jobs with high use of ICT (Song 2019).

Research on factors affecting job seekers' employment process has been ongoing (Park et al., 2020; Park et al., 2020). In recent years, a lot of research on career development using the National Competency Standards has been conducted in Korea. Among them, there is a study on a program that enhances competency and develops careers for women with career interruptions. IS Park, MN Lee, and DI Kim (2021) conducted a study targeting 30 career-interrupted women at a lifelong learning center in a specific region. The goal of this study was to better understand the process of assisting women whose careers have been interrupted so that they may effectively re-enter the workforce by offering a curriculum designed in accordance with the

National Competency Standards. Although the importance and effectiveness of the national competency standards could be confirmed, attention was paid to the fact that it confirmed the social atmosphere in which women with career interruptions needed to re-enter the labor market and strongly demanded national support (Park et al., 2021).

3. Research Methodology

3.1. Analysis process

The structure of this study can be broadly explained in three stages. First, based on the literature study reviewed above, the current status of women's participation in ICT was examined. In order to confirm the three-dimensional composition, the status of representatives of ICT companies was checked, and the overall employment size was investigated. Using this data, we compared and analyzed the employment size according to the gender of the representative.

Second, in order to confirm more specific data, raw data provided by the Ministry of Employment and Labor, which includes data by industry and position, was obtained and further analyzed. This data included corporate financial data, which played an important role in resolving research questions.

Third, the financial performance of ICT companies was compared by dividing them into a group with a high percentage of female workers and a group with a low ratio of female workers.

3.2. Analysis materials and methods

The data collection method used as the data for this study is as follows. The data in the first stage was organized by reprocessing the contents of the annual report provided by the Ministry of Information and Communication of Korea. The Labor Research Institute, a Korean Ministry of Employment and Labor organization, posts the data needed in step 2 on its website and provides raw data and survey results every two years. The address of the site where you can check this material is as follows. 'https://www.kli.re.kr/wps/index.do' This study includes a part that uses this data to classify groups of companies and compare their performance.

4. Research Results

4.1. Current status of woman representatives in the ICT industry

Table 2 shows the gender status of representatives organized based on the basic data of the '2018 ICT Survey' published by the Ministry of Science and ICT of Korea in 2019. In a total of 5,753 companies, 5,303 companies, or 92.2%, were represented by men, while 450 companies, or 7.8%, were represented by women (Ministry of Science, ICT and Future Planning(Korea) 2019).

Table 2. Current status of woman representatives in the ICT industry.

Division (sex of CEO)	Number of companies	percent	Effective percentage	Cumulative percent
Male	5303	92.2	92.2	92.2
Female	450	7.8	7.8	100.0
Sum	5753	100.0	100.0	

The division of the number of employees employed by each company is as Table 3. There were 1,570 companies in sections 10 to 19, which had the most distribution. On the other hand, only nine companies employed more than 1,000 people.

Table 3. Distribution of employees in ICT companies.

Worker section (people)		Number of companies	percent	Effective percentage	Cumulative percent
division	1: 1~4	718	12.5	12.5	12.5
	2: 5~9	1362	23.7	23.7	36.2
	3: 10~19	1570	27.3	27.3	63.4
	4: 20~49	1263	22.0	22.0	85.4
	5: 50~99	449	7.8	7.8	93.2
	6: 100~299	332	5.8	5.8	99.0
	7: 300~499	36	.6	.6	99.6
	8: 500~999	14	.2	.2	99.8
	9: 1000 or more	9	.2	.2	100.0
	Sum	5753	100.0	100.0	-

The smallest scale was set to 1 and the largest scale was set to 9 according to the workers' section, and it was checked according to the gender of the representative. As shown in Table 4, the average value of the man representative companies was 3.15 and the woman representative companies were 2.62. Although not a big difference, the man representative companies showed a large employment scale.

Table 4: Employee distribution by gender of CEO in ICT companies.

Representative' gender	Average	N	Standard Deviation
Man	3.15	5303	1.422
Woman	2.62	450	1.185
Sum	3.11	5753	1.412

4.2. Current status of woman employees in the ICT industry

The state of manpower by gender in the ICT sector and allied industries are as shown in Tables 5 and Table 6 of the "2018 ICT Manpower Trend Survey," which was published by the Ministry of Science and ICT in 2019. It was estimated by dividing it into all workers and regular workers. Among the total workers, 1,304,739 were

classified into 358,865 women and 945,874 men. In the case of full-time workers, the total was estimated at 1,182,572(329,686 for women, and 852,986 for men) (Ministry of Science, ICT and Future Planning (Korea) 2019).

Table 5: Status of total workers in the ICT industry.

division	ICT industry			ICT related industries			Sum		
	Sum	Man	Woman	Sum	Man	Woman	Sum	Man	Woman
2018 (Provisional value)	1,024,668	728,966	295,702	280,071	216,908	63,163	1,304,739	945,874	358,865

*Source: Ministry of Science and ICT(2019), ICT workforce trend survey [12]

Table 6: Status of full-time workers in the ICT industry.

division	ICT industry			ICT related industries			Sum		
	Sum	Man	Woman	Sum	Man	Woman	Sum	Man	Woman
2018 (Provisional value)	971,082	693,493	277,589	211,490	159,493	51,997	1,182,572	852,986	329,586

*Source: Ministry of Science and ICT(2019), ICT workforce trend survey (Ministry of Science, ICT and Future Planning(Korea) 2019).

4.3. Company panel raw data analysis provided by the ministry of employment and labor

In order to examine a little more specific personnel composition, we analyzed the business panel data released by the Ministry of Employment and Labor in 2018 (Ministry of Employment and Labor (Korea) 2018). The composition of all workers in the sample and the status of executives and managers, which can be called management positions, are summarized in Table 7. First, a total of 124 companies were involved in the manufacturing of electronic parts, computers, video, sound, and communication equipment, and the average number of workers was 245.81, with 5.52 man executives, 0.13 woman executives, 11.51 man managers, and the woman manager were 0.22. It can be said that the ratio of women in management positions is very low compared to the total number of workers. In the case of video and audio recording production and distribution, the average number of workers was 171.50, 4 man executives, 1.25 woman executives, 15.5 man managers, and 1.75 woman managers. In computer programming, system integration, and management, the average number of workers was 261.50, man executives were 6.05, woman executives were 0.05, man managers 32.77, and woman managers 3.36. In the information service industry, the average number of workers was 310.43, man

executives were 4.57, woman executives were 0.14, man managers were 15.14, and woman managers were 2.43.

Table 7: Gender status of managers by ICT industry

Industry classification		All workers	Male executive	Female executive	Male manager	Female manager
Electronic parts, computer, video, sound and communication equipment manufacturing industry	Average	245.81	5.52	.13	11.51	.22
	N	124	124	124	124	124
	S.D.	452.282	4.707	.337	22.876	.693
Video and audio recording production and distribution business	Average	171.50	4.00	1.25	15.50	1.75
	N	4	4	4	4	4
	S.D.	85.438	4.320	1.258	14.271	2.217
Broadcasting	Average	174.50	2.38	.00	11.88	.50
	N	8	8	8	8	8
	S.D.	180.636	1.408	.000	12.586	.756
Communication	Average	187.50	5.08	.25	12.83	1.33
	N	12	12	12	12	12
	S.D.	222.195	4.441	.866	24.605	4.313
Computer programming, system integration and management	Average	261.50	6.05	.05	32.77	3.36
	N	22	22	22	22	22
	S.D.	206.812	3.735	.213	37.221	6.336
Information service industry	Average	310.43	4.57	.14	15.14	2.43
	N	14	14	14	14	14
	S.D.	516.590	3.975	.363	31.968	6.035
Sum	Average	244.09	5.32	.15	14.52	.88
	N	184	184	184	184	184
	S.D.	408.171	4.443	.438	25.997	3.162

The gender ratio of all workers was measured by dividing the number of woman workers by the number of man workers. The main contents of Table 8 are as follows. The average was 0.59, and the information service industry recorded 1.12 with more women, while the computer programming, system integration, and management industry recorded 0.28. The total recorded 0.59, which was found to be less than 60% of man workers.

Table 8: Sex ratio of workers by ICT industry (woman/man)

Industry classification	Average	N	Standard Deviation
Electronic parts, computer, video, sound and communication equipment manufacturing industry	.6052	124	.66956
Video and audio recording production and distribution business	.6352	4	.18700
Broadcasting	.4098	8	.28590
Communication	.4294	12	.34995
Computer programming, system integration and management	.2842	22	.20275
Information service industry	1.1173	14	1.31370
Sum	.5865	184	.68958

4.3. Financial performance comparison

The corporate performance research when a woman held the top management position as well as the study on the impact of gender on the creativity and performance of SME managers were among the international studies that showed promising results. To further confirm this, a detailed classification analysis was performed (Tahir et al., 2021; Ali et al., 2020).

Table 9 summarizes the results of the comparison of sales and ordinary income for companies represented by men and companies represented by women. In terms of total sales, the average number of companies represented by men was 11,093 million won, and ordinary income was 825 million won. This was in contrast to the women's representative company showing 2,921 million won in sales and 82 million won in ordinary income. On the other hand, as a result of comparing only the sales in the information and communication sector, it was found that the man representative company was 4,155 million won and the woman representative company was 1,919 million won, which was relatively less than the total sales.

Table 9: Comparison of ICT industry representatives' financial performance by gender

Division	Representative's gender	N	Average (millions of Korean won)	Standard Deviation	Standard error of the mean
Total sales	Man	5303	11092.75	115776.227	1589.859
	Woman	450	2921.19	6046.377	285.029
Information Communication Sales	Man	5303	4154.62	16207.340	222.562
	Woman	450	1918.86	4225.768	199.205
Ordinary profit	Man	5303	825.53	21809.208	299.488
	Woman	450	82.33	870.025	41.013

In order to confirm the performance according to the gender ratio of the members, the comparison was conducted by dividing into companies with a ratio of women above average and those with below average. Groups were classified based on the average gender ratio (Woman workers/man workers) of 0.59 in the ICT field, and Table 10 is the comparison result. In terms of sales, the group with the ratio of women above the average showed a high, and the same pattern was shown in operating profit. However, in terms of net profit, the group with a ratio of women below the average was higher. In the per capita labor cost, the group with the ratio of women above the average recorded a low figure, and the added value per capita was found to be much higher.

Table 10: Comparison of financial performance according to the gender ratio of the ICT industry.

Division	Sex ratio : Woman/man (Sex Ratio Average=.59)	N	Average	Standard Deviation	Standard error of the mean
Total sales	>= .59	61	487974.5 ₂	2270913.64 ₃	290760.698
	< .59	123	281464.2 ₄	1592678.72 ₉	143607.005
Operating profit	>= .59	61	20294.56	113326.284	14509.944
	< .59	123	11636.91	78680.303	7094.364
Labor cost per person	>= .59	61	42.33852 ₅	18.3573102	2.3504127
	< .59	122	53.26319 ₇	23.0673272	2.0884177
Value added per person	>= .59	53	61.07320 ₈	58.6923769	8.0620180
	< .59	89	22.11988 ₈	483.886634 ₉	51.2918807

4.4. Summary of analysis results

A brief summary of statistical analysis is as follows. Women's roles were discovered to be comparatively weak in comparison to men's, but in businesses with a reasonably high representation of women, value-added output per employee was high and labor costs per employee were low. It can be said that the reason why the proportion of women in the ICT sector should increase has been partially confirmed.

5. Conclusions

The purpose of this study is to confirm the legitimacy of the policy to support female human resources by confirming the role of women in the ICT field. For this purpose, the following two research questions were established.

First, does the high participation rate of female workers in the ICT sector have a positive effect on the financial performance of companies or the process of producing efficient results? Second, does the policy direction that pursues the influence of female workers in the ICT sector help companies?

The answers to the two questions identified through this study are as follows. It is difficult to assert that the high participation rate of female workers plays a role in enhancing the financial performance of companies. However, as a result of analyzing a relatively large number of company data, we found signs of positive financial performance in companies with a high proportion of female workers. Although additional research is needed for each sub-area, general ICT companies can expect positive effects from policies that increase the proportion of female workers. It will be feasible to look favorably upon the rise in the percentage of female workers, not only in regards to maintaining gender equality, which is a social concern, but also in terms of production and efficiency. In addition, this study is different from other studies in that it was confirmed through quantitative analysis of data provided by Korean government agencies.

In Korea, there have also been studies on women's lack of ICT competency [7,8,11]. As the causes of these problems, the problem of career interruption due to childcare and the problem of lack of family rearing were suggested. If these social problems were solved, completely different results could be obtained. As a result of the low birth rate, the aging of the population, and the concomitant decline in the working population, the need of expanding the inflow and use of women's economic activities is being highlighted. A social phenomenon emphasizing inclusive growth, such as changes in the industrial structure, improvement of the level of the female workforce, and the realization of gender equality, is also increasing demands for the utilization of female workers and job creation for female workers. The results of this study are expected to play an important role in the connection between social demand and supply.

Additionally, the policy implications derived by synthesizing the results of this study and previous studies are as follows. First, since the influx of women into related majors is low, career education and experience opportunities for various occupations in the ICT field should be expanded. Second, the government should actively step forward to improve the corporate environment in the ICT field and promote active policies to resolve the gender imbalance. Third, various efforts are required to prevent women who work and raise children from deviating from the labor market and approaching in a variety of ways, from indirect directions such as creating a social atmosphere to active policies for the family balance of ICT women workers. Fourth, it is necessary to strengthen support for women who have experienced career interruption to return to work and reemployment. Additionally, they argued for the need to organize and support women's enterprise clusters.

As technology and industry converge on the basis of ICT, changes are expected in the demand for technology and manpower required by changes in the labor environment due to industrial restructuring, expansion of manpower fluidity and flexibility in working types, and the Fourth Industrial Revolution. The government encourages and supports women in ICT, women working in science and technology, and women entrepreneurs in response to population and industrial environment changes. It does this by fostering an environment that encourages their involvement in economic activities, improving key competencies in response to technological development, and promoting family balance. Various policies such as system activation have been established and implemented. These policies should be embodied in the direction of supporting women's current workforce to derive results in the ICT industry.

The limitations and future directions of this study are as follows. Due to the limitations of secondary data analysis, this study lacks in deriving a causal relationship for each detailed factor. Hence, this needs to be supplemented in the future. Data collection and analysis to confirm causation should be provided, along with analysis by specific region and detailed factors.

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