

# Output Cost of Gender Discrimination in the Korean Labour Market\*

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## Abstract

This study constructs and calibrates a macroeconomic model that explains Korea's glass ceiling and examines the output cost of gender discrimination. The model is based on the span-of-control framework in Lucas (1978). The model assumes that the source of the glass ceiling is that women are unable to accumulate as much managerial skill as men. According to the simulation results of a one-sector model, without the glass ceiling, the share of female managers increases, aggregate output increases by 7.2%, and the output gain by removing the glass ceiling is monotonic. However, the output gain by removing the glass ceiling in a two-sector model is non-monotonic because wages increase rapidly owing to high labour demand and the number of workers increase beyond a certain level, as per given parameters. The additional simulation results suggest that the effects of the policies in removing the glass ceiling on output will become monotonic if the government introduces policies to reallocate female employment from the service sector to the manufacturing sector.

Keywords: Gender discrimination; glass ceiling; managerial skill; aggregate output; span of control.

JEL classification: E2, J24, J71.

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## I. Introduction

Over the past few decades, Korea has achieved remarkable economic growth, narrowed the gender gap in education, and improved gender equality. However, gender equality remains an important issue in Korea. As of 2015, the labour force participation rate for women is 51.8%, which is 22 percentage points lower than that of men and below the OECD average of 60%. According to the economically active population survey by Statistics Korea (2015), the gender wage gap is at 62.8%.

The glass ceiling is an important form of discrimination in the Korean labour market; however, it receives less focus in the literature. The glass ceiling is rampant in the Korean labour market and is a barrier for women in achieving higher positions and career management. The Federal Glass Ceiling Commission (1995) in the United States categorises these barriers as follows: (1) societal barriers that may be outside of the workplace, (2) internal structural barriers within the workplace, and (3) governmental barriers. In the Korean context, the barriers in the first and second category are the priority. Women in their 20s and 30s feel burdened by the work and family balance and find it difficult to manage their careers. Poor career development and competitiveness also become barriers in promotion and maintaining position for women in their 40s and older (Kang 2013).<sup>1</sup> Despite the increase in numbers of highly educated women in the labour market, the trend is to exclude women from important positions and place them in specific occupations in lower-level positions (Kim et al. 2013). The glass ceiling lowers the career goals of women and hinders ambitions for promotion above certain levels (Kim 2013). The Federal Glass Ceiling Commission (1995) defines these discriminations as pipeline barriers, which are a series of glass ceilings in each career level.

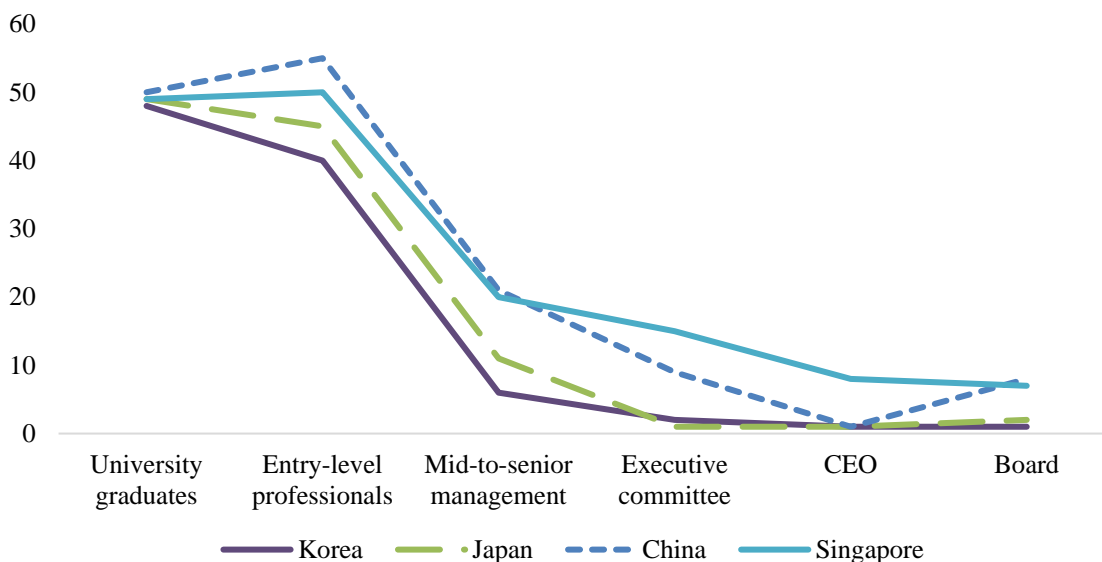
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<sup>1</sup> Although it is a contention that women in their 40s are less educated compared to men and few are likely to climb to senior management positions; therefore, the glass ceiling is not a problem. However, this argument does not hold, as the difference in the average years of schooling between men and women aged 40–49, who actively participate in the labour market, is only 0.8 years.

Figure 1 shows the existence of the glass ceiling in Asian countries. As of 2011, Korea has the strongest glass ceiling structure among major Asian economies. In low-level careers, the proportion of women is similar to that of men; however, this decreases sharply in the middle and higher levels. Therefore, an insufficient number of women receive promotions to middle or higher levels in an organisation.

Figure 1 may be the result of women not remaining in the labour market for the long term. However, it can be explained by the gender discrimination in promotion. Table 1 shows the proportion of promotion by position and gender, indicating that pipeline barriers may exist in the Korean labour market. Both women and men have similar probabilities of promotions at lower levels; however, the probability of promotion for women is lower than that of men at higher levels. This may be due to barriers that prevent women from jobs that are on the fast track to the top or have access to critical developmental assignments (Federal Glass Ceiling Commission 1995).

Figure 1 Glass ceilings in Asian countries (share of females in each position, as percentage)



Source: Süßmuth-Dyckerhoff et al. (2012), Women Matter: An Asian Perspective

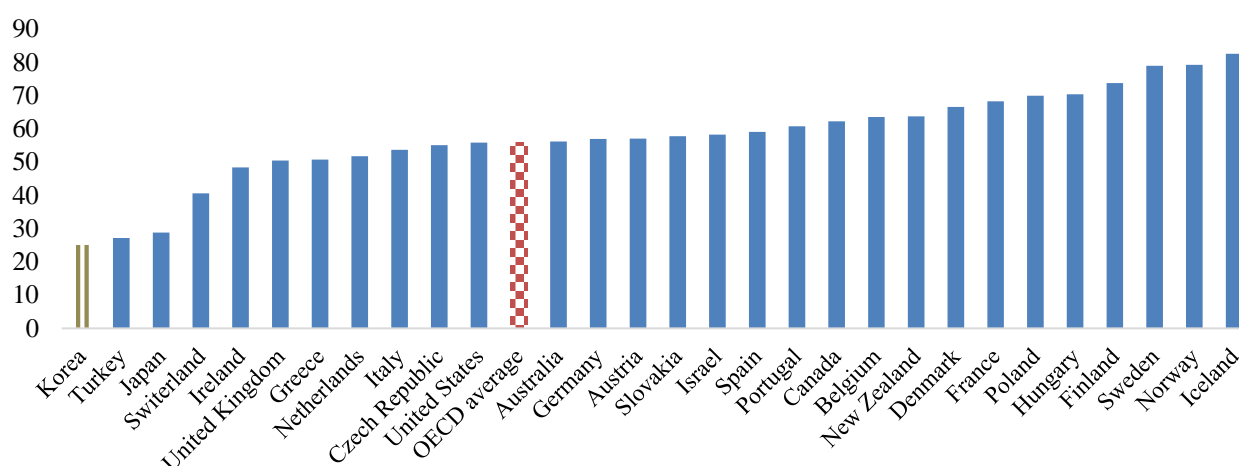
Table 1 Proportion of promotion by position and gender (percent)

	Staff→ Assistant manager	Assistant manager → Manager	Manager→ Deputy general manager	Deputy general manager→ General manager	General manager → Executive manager
Men	79	74	71	67	71
Women	75	70	65	54	43

Source: Author's calculation from the Ministry of Gender Equality and Family (2014), 2014 Korean women manager panel survey

Although not an exclusively Korean problem, the glass ceiling is more serious in Korea. Figure 2 shows the results of a glass-ceiling index created by the Economist (2016) in which Korea ranks last among 29 OECD countries. Indicators such as female labour force participation rate and female share of senior managerial positions and company boards are significantly lower than the OECD average. According to ILO (2016), the share of female managers in Korea is 11%, which ranks 97 out of 108 countries and is much lower than that of the United States, at 43.4%.

Figure 2 The glass ceiling index (2015)



Source: The Economist (2016)

Note: The maximum score is 100.

Table 2 shows managers' share of the labour force by gender and sector and share of female managers by industry. According to Statistics Korea's (2015) economically active population survey, managers' share of the labour force is 2.2% and the share of female managers in the economy is 9.0%. While the share of male managers in the male labour force is 3.2%, the share of female managers in the female labour force is 0.5%.

Table 2 Share of managers in the labour force by gender and sector, and share of female managers by sector (2015, percent)

	2015
<b>A. Total</b>	
Share of managers in the labour force	2.2
Share of female managers in the female labour force	0.5
Share of male managers in the male labour force	3.2
Share of female managers	9.0
<b>B. Manufacturing</b>	
Share of managers in the labour force	2.8
Share of female managers in the female labour force	0.1
Share of male managers in the male labour force	3.6
Share of female managers	0.9
<b>C. Service</b>	
Share of managers in the labour force	1.9
Share of female managers in the female labour force	0.7
Share of male managers in the male labour force	2.9
Share of female managers	15.4

Source: Author's calculation from Statistics Korea (2015)'s October 2015 economically active population survey

Note: The sample consists of regular workers at firms with more than 10 workers.

The glass ceiling is more serious in the manufacturing sector in comparison to the service sector. The share of female managers in the service sector is 15.4%; however, this is only 0.9% in the

manufacturing sector.<sup>2</sup> When comparing the share of female employees in both sectors (44% and 24% in services and manufacturing, respectively), the gap between the two sectors is astounding.

The existing literature does not extensively study the effect of the glass ceiling on aggregate output. Most studies focus on the effect of reduction in gender discrimination in the labour market on aggregate output or income per capita (Cavalcanti and Tavares, 2015; Kim et al., 2016; Ngai and Petrongolo; 2015), and the effect of the glass ceiling on labour market outcomes using microdata (Kim, 2013; Kang, 2013). In a recent study, Cuberes and Teignier (2016) focused on the effect of the glass ceiling on aggregate output. They imposed labour market frictions that prevented females from becoming employers.

This study constructs and calibrates a macroeconomic model that explains Korea's glass ceiling and examines the output cost of gender discrimination. The model is based on the span-of-control framework in Lucas (1978). In this model, individuals with high managerial skill become managers who earn profits, while others become workers who earn the equilibrium wage. I add three primary sources of gender discrimination in the Korean labour market to his model. First, women have lower labour force participation rates than men. Second, unlike men, women experience a glass ceiling of discrimination in promotions. Third, women receive less wages than men, irrespective of the glass ceiling, occupation, and position. The model assumes that the source of the glass ceiling is that women are unable to accumulate as much managerial skill as men. If women can accumulate as much managerial skill as men, the share and number of female managers will increase.

As in Lucas (1978) and Cuberes and Teignier (2016), the Pareto cumulative distribution gives the distribution of managerial skill. Klumpp and Su (2013) prove that a glass ceiling exists if the variance of skill distribution among men is higher than among women. If women are unable to accumulate as much managerial skill as men, the variance of skill distribution of men becomes

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<sup>2</sup> The sixth Korean standard classification of occupations defines 'managers' by considering the size of the management category, level of functioning, and the type of function.

higher than that of women. Using the 2014 Korean women manager panel survey, I test for gender difference in the Pareto cumulative distribution of managerial skill. The result shows that the variance of managerial skill distribution of women is lower than that of men.

In a one-sector model, the aggregate output increases by 7.2% when the glass ceiling disappears. The output gain from the removal of the glass ceiling is monotonic because the number of workers continues to decline and the number of managers continues to increase gradually.

An extended two-sector model shows results that are more accurate, as a one-sector model cannot reflect that the productivity of the manufacturing sector is greater than the service sector, but the glass ceiling is more prevalent in the former than in the latter. In a two-sector model, the aggregate output increases by 5.2% when the glass ceiling disappears. Unlike a one-sector model, the output gain from removing the glass ceiling is non-monotonic because wages increase rapidly owing to high labour demand and the number of workers increase beyond at a certain level as per given parameters. The additional simulation results suggest that policy effects in removing the glass ceiling will become monotonic if the government introduces policies to reallocate female employment from the service sector to the manufacturing sector.

This study contributes to the literature as follows: To my knowledge, no other Korean study quantitatively evaluates the output cost of gender discrimination using this model. This model considers that the glass ceiling is more serious in the manufacturing sector than in the service sector. Further, this study provides important policy implications by demonstrating the effect of various gender policies on actual output using macroeconomic models adapted to the Korean context.

The remainder of this paper is as follows. In Section 2, I review the literature linking gender discrimination, aggregate output, and labour market outcomes. Section 3 includes a macroeconomic model that explains Korea's glass ceiling and the numerical simulation results. Section 4 presents a two-sector economy and the numerical simulation results. Finally, Section 5 concludes the paper.

## **II. Literature review**

Cavalcanti and Tavares (2015) measure the output cost of gender discrimination. Their study shows that if the gender wage gap increases, it discourages female labour market participation and decreases output. Further, it increases fertility and population in the steady state and decreases the steady-state output. They use a growth model in which saving, fertility, and labour market participation are endogenous and the model imposes two gender discriminations. First, women have higher productivity in child rearing than men, and second, women earn less than men do despite having the same productivity. The model is calibrated to the US economy. According to the results, a 50% increase in the gender wage gap leads to a 35% decrease in per capita income.

Cuberes and Teignier (2016) evaluate the output cost of gender gap in entrepreneurship and labour force participation. They show that the gender gap in entrepreneurship has a negative effect on income and aggregate productivity. The model based on Lucas (1978)'s span-of-control framework, which is a general equilibrium occupational choice model, assumes that occupation is determined by an individual's entrepreneurial talent. It considers two genders: female and male, and no gender discrimination except two female labour market frictions. First, a certain fraction of women cannot freely choose their occupation, and second, the labour market expels a certain fraction of women. They too calibrate their model to the US economy. The results show that when women cannot be self-employed or employers, the steady-state output decreases by 11%. Furthermore, when no women can enter the labour market, the steady-state output decreases by 50%.

Ngai and Petrongolo (2015) show that the rise of the service sector reduces gender gaps in hours and wages. The reallocation of labour from the manufacturing sector (structural transformation) and the allocation of time from home sector (marketization) drive the service sector. The model has three sectors (goods, market services, and home services) and rationalises the process of structural transformation and marketization. Only goods and services are purchasable from the market. Goods



and services are poor substitutes, while market and home services are good substitutes. Women have a comparative advantage in producing services. The authors calibrate their model to the US economy. The results show that the model explains 50% the rise in women's market hours and a 20% rise in the gender wage ratio in the past 40 years.

To the best of my knowledge, Kim et al. (2016) is the only study that investigates the impact of gender inequality on long-term economic growth. Most studies focus on the effect of the glass ceiling on labour market outcomes using microdata.

Kim et al. (2016) show that gender equality policies that lower gender discrimination in the labour market and the increasing time that fathers' spend on child rearing can contribute to a rise in female labour force participation rates and per capita income growth. The idea is that gender equality affects time allocation for work, household production, child rearing, and child education. It also stimulates human capital accumulation; therefore, gender equality affects economic growth. The model introduces two major gender discriminations in Korea. First, men spent less time on child rearing and child education than women did. Second, women earn less than their productivity. Once these gender differences disappear, the female labour participation rate increases from 54.4% to 67.5% and the per capita income growth rate increases from 3.6% to 4.1%.

Kim (2013) empirically investigates the determinants of female career goals using the 2008, 2010, and 2012 Korean women manager panel survey. The results show that most female managers downgrade their career goals over time and do not expect promotion to top positions. Further, it shows that women who graduate from university or earn high wages desire promotions. Tenure is not statistically significant; its interpretation is implicitly recognising the position of promotion within a firm, regardless of how long it may be. Marital status is also not statistically significant because the average age of female managers in the sample is 38 and 72% of women were married. The results can also be due to a sample selection of women who cannot overcome the glass ceiling and retire or leave the sample. One limitation of this study is that the data has only female samples and cannot

analyse if these determinants only affect women.

Kang (2013) empirically investigates the determinants of female promotion in organisations using the 2007 and 2012 Korean women manager panel survey. The author assumes that the determinants of female promotion can differ with position because women face different life cycle, company requirements, and labour market circumstances than men. This study estimates a logit model with a dependent variable: female managers promoted over five years. The results show that females under the age of 30 or in junior positions have a high probability of promotion. Marital status is not statistically significant. The years of education are significant for promotion in junior positions, but not for middle-to-high positions. Any policies for job and family balance are also not statistically significant. Females in the financial, retail, and business service sectors have a high probability of promotion compared with those in the manufacturing sector. One limitation of this study is that it cannot avoid sample selection bias, as it analyses only those cases in which women have been promoted for five years.

### **III. A one-sector model**

I present a macroeconomic model of gender discrimination in the Korean labour market to explain Korea's glass ceiling. The model is based on the span-of-control framework in Lucas (1978), which selects occupations based on the size of individual managerial skill. It calculates the ratio of managers and workers in the labour force and measures the size of enterprises. Cuberes and Teignier (2016) used this model to measure the decline in output resulting from the non-promotion of women as managers. Although a simple model has only one economic sector, I extend this model to include two sectors; namely, manufacturing and service, in a later section.

#### **1. Model setting**

The economy has a continuum of women and men in a ratio of 1:1. The characteristics of

women and men are as follows. First, women and men attain the same level of education and enter the labour market. Second, women have lower labour force participation rates than men. Third, unlike men, women experience a glass ceiling of discrimination in promotions. Fourth, women receive less than equilibrium wages ( $w$ ) irrespective of glass ceiling, occupation, and position. While men receive  $w$ , women receive  $\emptyset w$ , where  $\emptyset \in (0,1)$ . The last three characteristics are the primary source of gender discrimination in the Korean labour market. This implies that capable women are unable to participate in the labour market, receive lower wages, and do not reach higher positions.

Individuals have managerial skill  $z$ , drawn from a cumulative distribution that takes values between  $B$  and  $\infty$ . Individuals with high managerial skill become managers who earn profits, while others become workers who earn the equilibrium wage. As in Lucas (1978) and Cuberes and Teignier (2016), the Pareto cumulative distribution in Equation (1) gives the distribution of managerial skill as follows:

$$F(z) = 1 - B^\tau z^{-\tau}, z > 0 \quad - (1),$$

where  $\tau$  is the curvature of distribution.

Females (or males) allocate a  $\lambda$  fraction of time to the labour market and a  $1 - \lambda$  fraction of time to household production.  $\lambda$  is given exogenously.  $\lambda_f$  and  $\lambda_m$  are same as the labour force participation rates of females and males.

The production function is given by

$$Y_i = z \left( L_f^\xi L_m^{1-\xi} \right)^\gamma \quad - (2),$$

where  $\xi \in (0,1)$  and  $\gamma \in (0,1)$ .  $z$  is the managerial skill of the firm's manager.  $L_f$  and  $L_m$  are female and male labour inputs of the firm.  $\gamma$  is the span-of-control parameter.<sup>3</sup>

## 2. Glass ceiling and managerial skill

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<sup>3</sup> The economy has only one manager if the span-of-control parameter is 1. More than one manager exists in a production function with diminishing returns to scale.

The model assumes that the source of the glass ceiling is that women are unable to accumulate as much managerial skill as men. The gender difference in managerial skill is not the only cause of the glass ceiling; however, several theoretical and empirical studies support this assumption. First, Klumpp and Su (2013) prove that a glass ceiling exists if the variance of skill distribution among men is higher than among women. If women are unable to accumulate as much managerial skill as men, the variance of skill distribution of men becomes higher than that of women. Second, an unfriendly corporate culture for women can prevent them from expressing their entrepreneurial capabilities. Women also have a limited ability to accumulate managerial skill because they prefer part-time jobs or balance work and family (Cuberes and Teignier 2016). In Korean organisational culture, women are excluded from core jobs or core manpower and set low career goals for themselves owing to the glass ceiling (Kim et al., 2013; Kim, 2013). Therefore, despite the same education, there exists a gender gap in managerial skill among males and females.

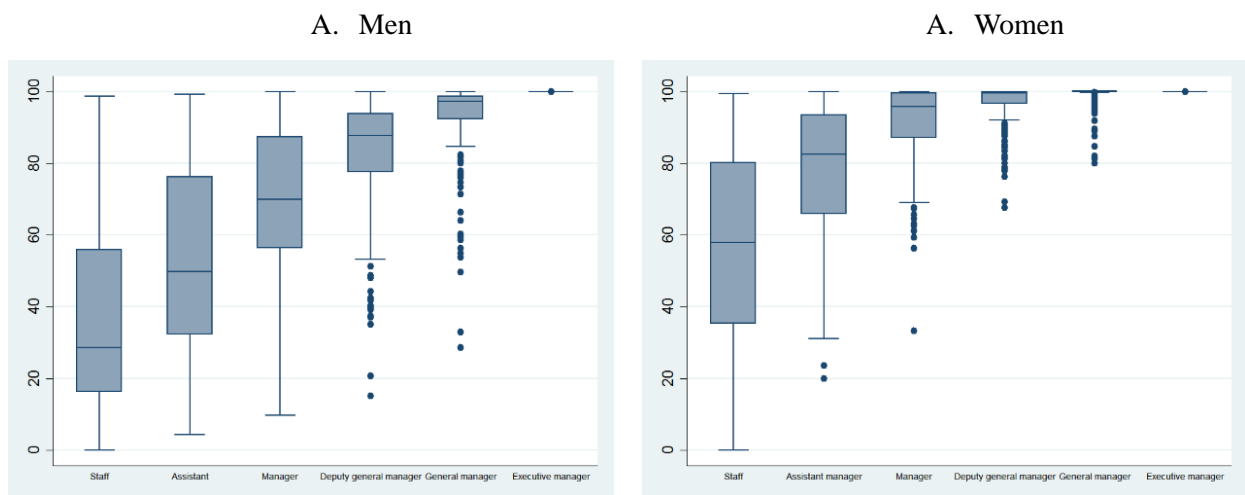
There are various ways to measure managerial skill; however, this study assumes that managerial skill is proportional to position. Although men and women work in the same place and attain the same level of education, a difference exists in the accumulation of managerial skill, even in the same position. Women experience gender discrimination in promotion due to gender differences in managerial skill and there is a smaller pool of women in high-level positions. This leads to a difference in the shape parameter of the Pareto cumulative distribution in the model.

$$\text{Pareto cumulative distribution of managerial skill} = 1 - \left(\frac{1}{z}\right)^\gamma - (3)$$

I test for gender difference in the Pareto cumulative distribution of managerial skill, using the 2014 Korean women manager panel survey. Equation (3) is the Pareto cumulative distribution of managerial skill to be tested.  $z$  is position and  $\gamma$  is a curvature of distribution. Figure 3 shows a box plot of cumulative distribution of regular employees by position and gender using information from 228 companies. Comparing Figure 3A and Figure 3B, the curvature of men's distribution is smaller than that of women's. The results show that the estimated distribution curvature for men is

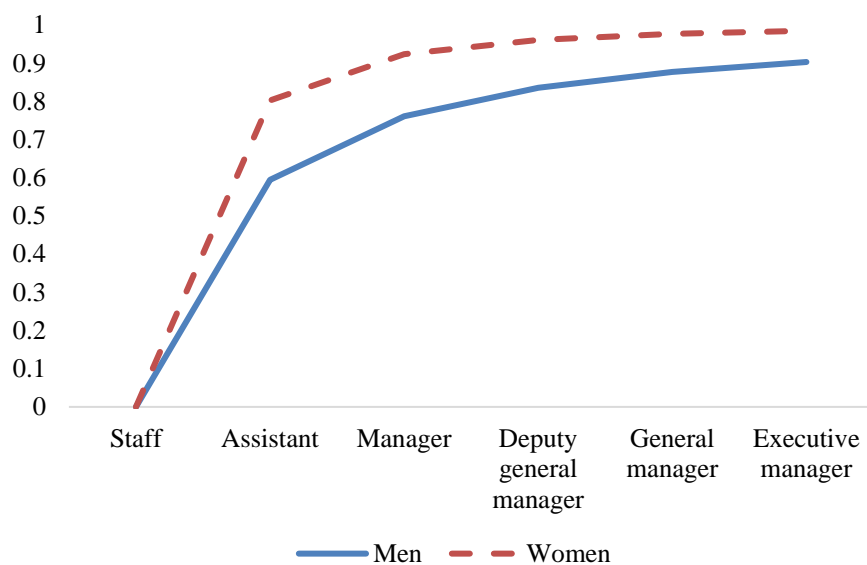
1.30 ( $s.e = 0.04$ ) and for women is 2.34 ( $s.e = 0.10$ ). Figure 4 is the estimated Pareto cumulative distribution of regular employees by position and gender. It shows that women may have lower managerial skill because many are in lower positions. It also shows that the variance of managerial skill distribution of women is lower than that of men.

Figure 3 Box plot of cumulative distribution of regular employees by position and gender (percent)



Source: Author's calculation from the Ministry of Gender Equality and Family (2014), 2014 Korean women manager panel survey

Figure 4 Estimated cumulative distribution of regular employees by position and gender



For easier calculation, the model fixes the curvature of distribution ( $\gamma$ ) and assumes that the minimum value of support for female distribution ( $B_f$ ) is smaller than that of male distribution ( $B_m$ ). Although, managerial skill can dynamically accumulate over time, the model assumes that it is randomly given owing to the limitations of the static model.

### 3. Individual's optimization

#### A. Manager

Managers hire both female and male labour inputs to maximise profits. The optimal numbers of female and male labour inputs are increasing functions of the managerial skill  $z$ , as equations (4) and (5) show:

$$L_f(z) = \frac{\xi\gamma}{w} \left[ Az \left( \frac{\xi\gamma}{\phi w} \right)^{\xi\gamma} \left( \frac{(1-\xi)\gamma}{w} \right)^{(1-\xi)\gamma} \right]^{\frac{1}{1-\gamma}} - (4)$$

$$L_m(z) = \frac{(1-\xi)\gamma}{w} \left[ Az \left( \frac{\xi\gamma}{\phi w} \right)^{\xi\gamma} \left( \frac{(1-\xi)\gamma}{w} \right)^{(1-\xi)\gamma} \right]^{\frac{1}{1-\gamma}} - (5)$$

#### B. Worker

Figure 5 Occupational choice

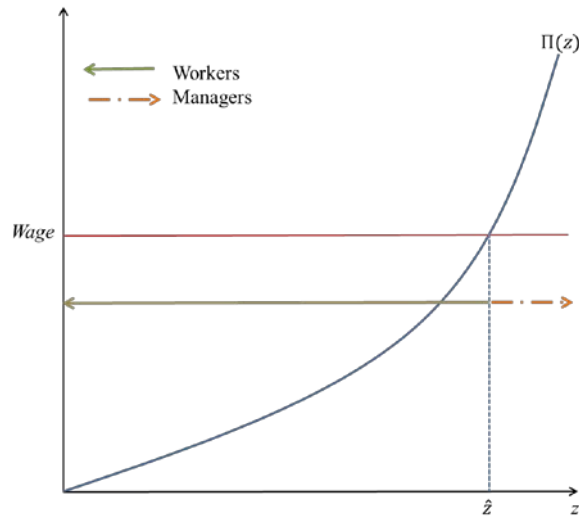


Figure 5 shows an individual's occupational choice under managerial skill  $z$ . The profit  $\Pi(z)$  is an increasing function of  $z$ .  $\hat{z}$  is the managerial skill cutoff for the occupational choice. If an

individual's managerial skill is less than the cutoff, the individual chooses to become a worker, if it is more the individual chooses to become a manager.  $\widehat{z}_f$  and  $\widehat{z}_m$  are cutoffs for female and male managerial skill. All other things being equal, the male managerial cutoff is larger than the female cutoff owing to the gender wage gap  $\emptyset$ .

If women can accumulate as much managerial skill as men, it does not change the managerial skill cutoff  $\widehat{z}$ ; however,  $\Gamma(\widehat{z})$  decreases. Therefore, the share and number of female managers increase.

#### 4. Competitive equilibrium

In equilibrium, the labour market must be clear. The equilibrium wage  $w^*$  is the market-clearing wage and Equation (8) is the labour market clearing condition. The left-hand side of Equation (8) is the labour supply, while the right-hand side is the labour demand. The first term on the left-hand side is the labour supply of females and the second term is the labour supply of males. The first brace on the right-hand side is the labour demand of female managers and second brace is that of male managers.

$$\lambda_f F(\widehat{z}_{f1}^*) + \lambda_m F(\widehat{z}_{m1}^*) = \left[ \lambda_f \int_{\widehat{z}_f}^{\infty} L_f(z, w^*) f(z) dz + \lambda_m \int_{\widehat{z}_f}^{\infty} L_f(z, w^*) f(z) dz \right] + \left[ \lambda_f \int_{\widehat{z}_m}^{\infty} L_f(z, w^*) f(z) dz + \lambda_m \int_{\widehat{z}_m}^{\infty} L_f(z, w^*) f(z) dz \right] \quad - (8)$$

A competitive equilibrium is  $\{L_f(z), L_m(z), \widehat{z}_f, \widehat{z}_m, w^*\}$  such that the individual's occupational choice is resolved and the labour market is clear.

#### 5. Numerical results of the one-sector model

##### A. Calibration and results

Table 3 shows the parameter values used in the benchmark model simulation. Most parameters are from the economically active population survey of Statistics Korea (2015). Span-of-control

parameter ( $\gamma$ ) and the parameters of Pareto cumulative distribution are matched to managers share of the labour force by gender and share of female managers in 2015.  $\xi$  is the female income share in 2015.  $\lambda_f$  and  $\lambda_m$  are female and male labour force participation rates in 2015. The gender wage gap ( $\phi$ ) is the value controlling for occupation and position, using the results of Statistics Korea (2015) and Kim (2009).

Table 3 Parameter values

Parameter	Value	Data or Targets
Span-of-control parameter ( $\gamma$ )	0.83	Match to Statistics Korea (2015)
Female income share ( $\xi$ )	0.39	Statistics Korea (2015)
Gender wage gap ( $\phi$ )	0.88	Statistics Korea (2015) and Kim (2009)
Female and male labour force participation rates ( $\lambda_f, \lambda_m$ )	0.52, 0.74	Statistics Korea (2015)
Curvature of Pareto cumulative distribution ( $\tau$ )	6.9	Match to Statistics Korea (2015)
Minimum value of support of Pareto cumulative distribution ( $\mathbf{B}_f, \mathbf{B}_m$ )	1, 1.36	Match to Statistics Korea (2015)

Table 4 Calibration results (percent)

	Target (2015)	Benchmark estimates
Managers share in the labour force	2.2	2.4
Share of female managers in the female labour force	0.5	0.5
Share of male managers in the male labour force	3.2	3.7
Share of female managers	9.0	8.8

Source: Author's calculation from Statistics Korea's (2015) October 2015 economically active population survey; author's calculation from the model



Table 4 shows benchmark estimates and target values in 2015. The target values are from the economically active population survey by Statistics Korea (2015). Benchmark estimates are similar to the target. The model implies that the share of managers in the labour market is 2.4% and the share of female managers is 8.8%. While the share of male managers in the male labour force is 3.7%, the share of female managers in the female labour force is 0.5%.

## B. Simulation results

Table 5 Simulation results (percent)

	(1)	(2)	(3)	(4)
	Benchmark estimates	No glass ceiling ( $B_f \rightarrow B_m$ )	No labour force participation rate gap ( $\lambda_f \rightarrow \lambda_m$ )	No labour force participation rate gap and glass ceiling ( $\lambda_f \rightarrow \lambda_m$ , $B_f \rightarrow B_m$ )
Managers share in the labour force	2.4	2.5	2.7	2.9
Share of female managers in the female labour force	0.5	2.7	0.6	2.6
Share of male managers in the male labour force	3.7	2.3	4.1	2.3
Share of female managers	8.8	44.9	12.1	53.7
Aggregate output	100.0	107.2	113.1	123.2

Notes: The figures in red (blue) letters indicate that the values of the variables increase (decrease) with the shocks.

Table 5 reports the simulation results if gender discrimination disappears.<sup>4</sup> Column (1) shows the benchmark estimates. The simulated aggregate output estimates may be underestimated because some parameters including labour force participation rates are exogenous in the model, which excludes the household production and childbearing decisions of women. A disappearance in gender discrimination can affect these parameters.

The aggregate output increases by 7.2% when the glass ceiling disappears in Column (2). As women can accumulate similar managerial skill as men, the number of female managers, and their share in the female labour force increases. Once the labour supply of females reduces due to the increase in female managers, the equilibrium wage, and managerial cutoff for males increase. Subsequently, the number of male managers and their share in the male labour force decreases. Therefore, able women who cannot become managers become managers, while men with less ability who are managers become workers. The increase in female managers offsets the decline in male managers; therefore, the total number of managers and their share in the labour force increases. The share of female managers in all sectors is 44.9%, which is close to 50%.

When the labour force participation rates of women reach that of men (Column (3)), aggregate output increases by 13.1%. As the female labour supply increases due to the increase in female labour force participation rates, the equilibrium wage and managerial cutoff for both genders decrease. The number of female and male managers and workers increase; consequently, all figures in Table 5 increase. Thus, the aggregate output in Column (3) is larger than that in Column (2).

The aggregate output increases by 23.2% when gender wage gaps disappear and labour force participation rates of women reach that of men (Column (4)). The change in figures is similar to that in Column (2) and Column (3).

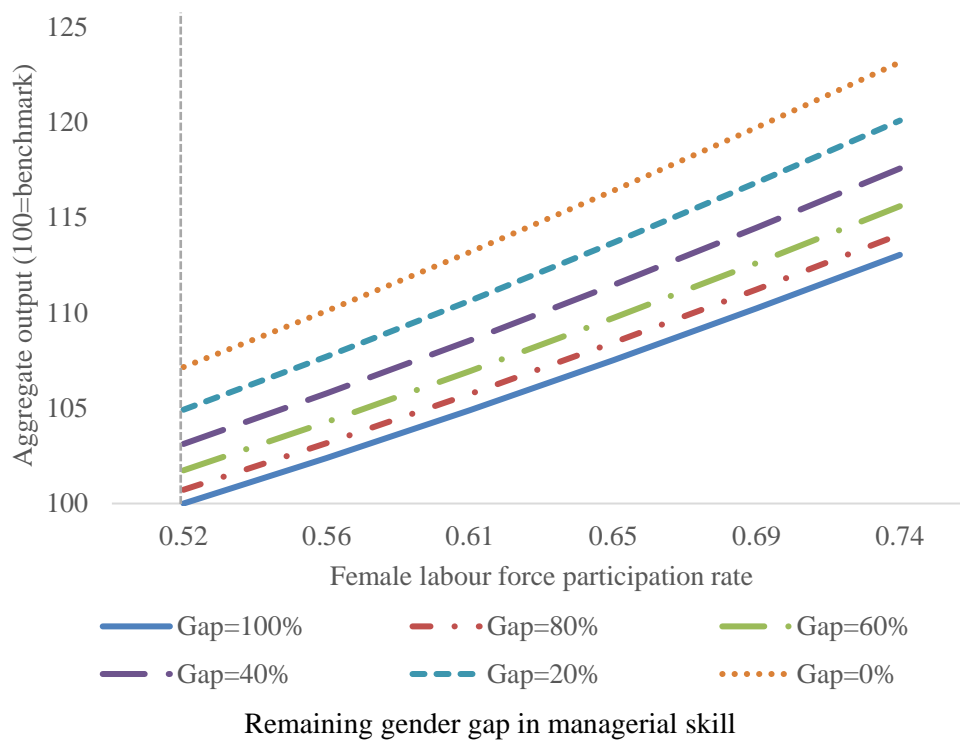
Figure 6 shows the aggregate output corresponding to the changes in female labour force

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<sup>4</sup> I also calculate the simulation result when the gender wage gap disappears. The aggregate output decreases by 0.8%, as female managerial skill cutoff increases and the number of managers decrease. This is possibly an underestimation, as the female labour participation rate must increase when the gender wage gap disappears.

participation rates ( $\lambda_f$ ) and the minimum value of support of female managerial skill distribution ( $B_f$ ). In this simulation, I reduce the gender gap in managerial skill and labour force participation rate by 20% until the gender gap disappears. The narrowing gender gap in the labour force participation rate is more effective in increasing aggregate output. The output gain from the removal of the glass ceiling is monotonic because the number of workers continues to decline. In addition, the number of female managers increases dramatically as managerial skill increases. The output of female managers surpasses that of male managers, and output gain grows larger. Figure 6 implies that the more the glass ceiling disappears, the more effective the policy will be.

Figure 6 Effects of narrowing gender gap in managerial skill and labour force participation rate on aggregate output



Note: The intersection point of the grey dotted line and the x-axis is the benchmark estimate of the aggregate output.

#### IV. A two-sector model

I extend this model to include two sectors: manufacturing and service. Females in the service

sector have a higher probability of promotion than those in manufacturing (Kang 2013). While the share of female managers in the service sector is 15.4%, it is 0.9% in the manufacturing sector, as seen in Table 2. Although some parameters for a two-sector model are exogenous, it can help in policy-making on gender equality. An empirical study by Lim (2008) shows that companies with a male-centred organisational culture have less participation of women in their management; however, women actively participate in the management of companies with a democratic organisational culture. In the Korean context, male-centric companies are in the manufacturing sector, while democratic companies are in the service sector. Therefore, the effect of policies directed at removing the glass ceiling may differ across sectors. Both industries have glass ceilings in the model.

## 1. Model setting

In a two-sector model, the fact that women contribute more in producing services than goods is added to the list of characteristics of women and men.

An  $\alpha$  fraction of women (or men) become managers in the service sector or workers in both sectors. On the contrary,  $1 - \alpha$  fraction of women (or men) become managers in the manufacturing sector or workers in both sectors.  $\alpha_f$  is larger than  $\alpha_m$  to take into account the characteristics of the Korean labour market.

A two-sector model assumes that the minimum value of support of distribution for those in the service sector ( $B_f^1$ ) is higher than for those in the manufacturing sector ( $B_f^2$ ) to assess why females in the manufacturing sector have lower probability of promotion than those in the service sector. Similar to a one-sector model, both values are less than the minimum value of support of male's distribution ( $B_m$ ).

Equation (9) is the production function for industry  $i$ . Industry 1 produces services while Industry 2 produces goods.  $A_i$  is the technology of industry  $i$ .  $z_i$  is the managerial skill of industry  $i$ 's manager.  $L_{fi}$  and  $L_{mi}$  are female and male labour inputs of industry  $i$ .  $\xi_1 > \xi_2$  is imposed

considering that women produce more services than goods.  $p_i$  is the price of outcome of industry  $i$ . The price of goods  $p_2$  is normalized to 1.  $\gamma$  is the span-of-control parameter where  $\gamma \in (0,1)$ .

$$Y_i = p_i A_i z_i \left( L_{fi}^{\xi_i} L_{mi}^{1-\xi_i} \right)^\gamma, i = 1(\text{service}), 2(\text{manufacturing}) \quad - (9)$$

A representative household consists of all females and males and consumes their wages and profits. Equation (10) is the utility function of a representative household.  $C_1$  and  $C_2$  are services and goods.  $\rho$  is the services share of total consumption.

$$U(C_1, C_2) = \ln(C_1^\rho C_2^{1-\rho}) \quad - (10)$$

Equation (11) is the budget constraint of a household. The consumption of services and goods must be equal to the sum of wages and profits.  $p_1$  is the price of services.  $\lambda_f$  and  $\lambda_m$  are a fraction of time to labour market of both females and males.  $w$  is the wage and  $\phi$  is the gender wage gap.  $\widehat{z}_{f1}, \widehat{z}_{f2}, \widehat{z}_{m1}$  and  $\widehat{z}_{m2}$  are the cutoff values for becoming managers in each sector and for each gender. The left-hand side of Equation (11) is the consumption of services and goods and the right-hand side is the sum of wages and profits.

$$\begin{aligned} p_1 C_1 + C_2 = & \lambda_f w \phi \left[ \alpha_f F_1(\widehat{z}_{f1}) + (1 - \alpha_f) F_2(\widehat{z}_{f2}) \right] + \lambda_m w \left[ \alpha_m F_1(\widehat{z}_{m1}) + (1 - \alpha_m) F_2(\widehat{z}_{m2}) \right] + \\ & \lambda_f \alpha_f \int_{\widehat{z}_{f1}}^{\infty} \pi_1(z, w, p_1) f_1(z) dz + \lambda_f (1 - \alpha_f) \int_{\widehat{z}_{f2}}^{\infty} \pi_2(z, w) f_2(z) dz + \\ & \lambda_m \alpha_m \int_{\widehat{z}_{m1}}^{\infty} \pi_1(z, w, p_1) f_1(z) dz + \lambda_m (1 - \alpha_m) \int_{\widehat{z}_{m2}}^{\infty} \pi_2(z, w) f_2(z) dz \quad - (11) \end{aligned}$$

## 2. Competitive equilibrium

In equilibrium, the labour market and markets for both goods must clear. The equilibrium wage  $w^*$  is the market-clearing wage. Equation (12) is the labour market clearing condition. The left-hand side of Equation (12) is the labour supply and the right-hand side is labour demand. The first brace in left-hand side is female labour supply and the second brace is male labour supply. The first and third braces on the right-hand side are the female managers' labour demand and second and fourth braces are the male managers' labour demand.

$$\begin{aligned}
& [\lambda_f \alpha_f F_1(\widehat{z}_{f1}^*) + \lambda_f (1 - \alpha_f) F_2(\widehat{z}_{f2}^*)] + [\lambda_m \alpha_m F_1(\widehat{z}_{m1}^*) + \lambda_m (1 - \alpha_m) F_2(\widehat{z}_{m2}^*)] = \\
& \left[ \lambda_f \alpha_f \int_{\widehat{z}_{f1}^*}^{\infty} L_{f1}(z, w^*, p_1^*) f_1(z) dz_1 + \lambda_f (1 - \alpha_f) \int_{\widehat{z}_{f2}^*}^{\infty} L_{f2}(z, w^*) f_2(z) dz_2 \right] + \\
& \left[ \lambda_m \alpha_m \int_{\widehat{z}_{m1}^*}^{\infty} L_{f1}(z, w^*, p_1^*) f_1(z) dz_1 + \lambda_m (1 - \alpha_m) \int_{\widehat{z}_{m2}^*}^{\infty} L_{f2}(z, w^*) f_2(z) dz_2 \right] + \\
& \left[ \lambda_f \alpha_f \int_{\widehat{z}_{f1}^*}^{\infty} L_{m1}(z, w^*, p_1^*) f_1(z) dz_1 + \lambda_f (1 - \alpha_f) \int_{\widehat{z}_{f2}^*}^{\infty} L_{m2}(z, w^*) f_2(z) dz_2 \right] + \\
& [\lambda_m \alpha_m \int_{\widehat{z}_{m1}^*}^{\infty} L_{m1}(z, w^*, p_1^*) f_1(z) dz_1 + \lambda_m (1 - \alpha_m) \int_{\widehat{z}_{m2}^*}^{\infty} L_{m2}(z, w^*) f_2(z) dz_2] \quad - (12)
\end{aligned}$$

The equilibrium price of services  $p_1^*$  is calculated from the first order condition of household (Equation (13)) and market-clearing condition for goods and services (Equations (14) and (15)).

$$C_1^* = p^* \left( \frac{\rho}{1-\rho} \right) C_2^* \quad - (13)$$

$$C_1^* = \lambda_f \alpha_f \int_{\widehat{z}_{f1}^*}^{\infty} y_{f1}(z_1, w^*, p_1^*) f_1(z_1) dz_1 + \lambda_m \alpha_m \int_{\widehat{z}_{m1}^*}^{\infty} y_{m1}(z_1, w^*, p_1^*) f_1(z_1) dz_1 \quad - (14)$$

$$C_2^* = \lambda_f (1 - \alpha_f) \int_{\widehat{z}_{f2}^*}^{\infty} y_{f2}(z_2, w^*) f_2(z_2) dz_2 + \lambda_m (1 - \alpha_m) \int_{\widehat{z}_{m2}^*}^{\infty} y_{m2}(z_2, w^*) f_2(z_2) dz_2 \quad - (15)$$

A competitive equilibrium is  $\{C_1^*, C_2^*, L_{f1}(z), L_{m1}(z), L_{f2}(z), L_{m2}(z), \widehat{z}_{f1}^*, \widehat{z}_{f2}^*, \widehat{z}_{m1}^*, \widehat{z}_{m2}^*, w^*, p_1^*\}$

such that the individuals' occupational choice is resolved and the labour market and markets for goods and services is clear.

### 3. Calibration and results

Table 6 shows the parameter values used in a two-sector model simulation. I use the same values for span-of-control parameter ( $\gamma$ ), the gender wage gap ( $\phi$ ), labour force participation rates by gender ( $\lambda_f$  and  $\lambda_m$ ), the curvature of Pareto cumulative distribution ( $\tau$ ), and the parameters of the male Pareto cumulative distribution ( $B_m$ ). The parameters of the female Pareto cumulative distribution ( $B_f^1, B_f^2$ ) are matched to the managers share in the labour force by gender and sector, and the share of female managers by industry in 2015. The weighted average of  $B_f^1$  and  $B_f^2$  is the same as  $B_f$  in a one-sector model.  $\alpha_f$  is the service sector share of female labour force and  $\alpha_m$  is the

service sector share of male labour force in 2015.  $\xi_1$  is the share of female income in the service sector in 2015.  $\xi_2$  is the share of female income in the manufacturing sector and adjusted to satisfy the labour market equilibrium condition. The original number of  $\xi_2$  is 0.16.  $\rho$  is the share of the service sector in the GDP in 2015. The productivity gap between the service and the manufacturing sectors  $A_1/A_2$  is from Lee and Song (2014).

Table 6 Parameter values for a two-sector model

Parameter	Value	Data or Targets
Span-of-control parameter ( $\gamma$ )	0.83	Match to Statistics Korea (2015)
Service sector share of female labour force ( $\alpha_f$ )	0.78	Statistics Korea (2015)
Service sector share of male labour force ( $\alpha_m$ )	0.58	Statistics Korea (2015)
Share of female income in the service sector ( $\xi_1$ )	0.35	Statistics Korea (2015)
Share of female income in the manufacturing sector ( $\xi_2$ )	0.26	Adjust to satisfy the labour market equilibrium condition
Productivity gap between the service and manufacturing sectors ( $A_1/A_2$ )	0.56	Lee and Song (2014)
Gender wage gap ( $\phi$ )	0.87	Statistics Korea (2015) and Kim (2009)
Female and male labour force participation rates ( $\lambda_f, \lambda_m$ )	0.52, 0.74	Statistics Korea (2015)
Service sector share of GDP ( $\rho$ )	0.61	Statistics Korea (2015)
Curvature of Pareto cumulative distribution ( $\tau$ )	6.9	Match to Statistics Korea (2015)
Minimum value of support of Pareto cumulative distribution ( $B_f^1, B_f^2, B_m$ )	1.05 0.78, 1.36	Match to Statistics Korea (2015)

Table 7 Two-sector model calibration results (percent)

	Target (2015)	Benchmark Estimates
<b>A. Total</b>		
Share of managers in the labour force	2.2	2.6
Share of female managers in the female labour force	0.5	0.6
Share of male managers in the male labour force	3.2	4.0
Share of female managers	9.0	9.8
<b>B. Manufacturing</b>		
Share of managers in the labour force	2.8	2.9
Share of female managers in the female labour force	0.1	0.1
Share of male managers in the male labour force	3.6	4.0
Share of female managers	0.9	0.9
<b>C. Service</b>		
Share of managers in the labour force	1.9	2.4
Share of female managers in the female labour force	0.7	0.8
Share of male managers in the male labour force	2.9	4.0
Share of female managers	15.4	15.3

Source: Author's calculation from Statistics Korea's (2015) October 2015 economically active population survey; author's calculation from the model

Table 7 shows estimates of a two-sector model and target values in 2015. Benchmark estimates are similar to the target.

#### 4. Simulation results

Table 8 reports the simulation results in a two-sector model without gender discrimination.<sup>5</sup>

<sup>5</sup> I also calculate the simulation result when the gender wage gap disappears. The aggregate output decreases by 0.3%, as female managerial skill cutoff increases and the number of managers decrease. The explanation is the same as in footnote



Column (1) shows the estimates of a two-sector model.

Table 8 Two-sector model simulation results (percent)

	(1) Benchmark estimates	(2) No glass ceiling ( $B_f^1, B_f^2 \rightarrow$ $B_m$ )	(3) No labour force participation rate gap ( $\lambda_f \rightarrow \lambda_m$ )	(4) No labour force participation rate gap and glass ceiling ( $\lambda_f \rightarrow \lambda_m,$ $B_f^1, B_f^2 \rightarrow B_m$ )
<b>A. Total</b>				
Share of managers in the labour force	2.59	2.62	3.0	3.0
Share of female managers in the female labour force	0.6	2.8	0.7	2.6
Share of male managers in the male labour force	4.0	2.5	4.4	2.4
Share of female managers	9.8	43.8	13.1	52.1
<b>B. Manufacturing</b>				
Share of managers in the labour force	2.9	3.0	3.0	3.0
Share of female managers in the female labour force	0.10	3.3	0.11	3.3
Share of male managers in the male labour force	4.0	2.8	4.5	2.8
Share of female managers	0.9	30.0	1.3	37.9
<b>C. Service</b>				
Share of managers in the labour force	2.41	2.44	2.3	2.3
Share of female managers in the female labour force	0.76	2.6	0.82	2.4
Share of male managers in the male labour force	4.0	2.3	4.3	2.1
Share of female managers	15.3	52.3	20.5	60.9
Aggregate output	100.0	105.2	113.2	118.9

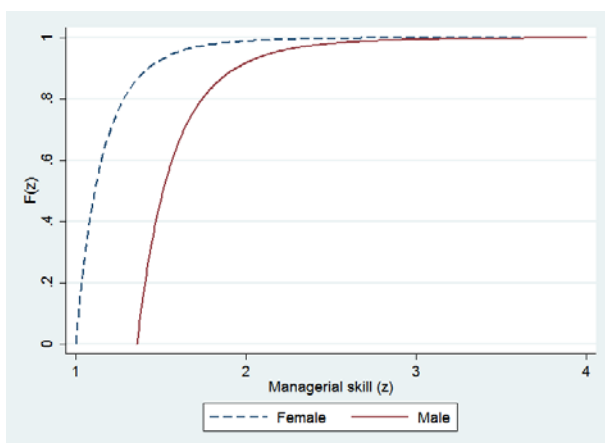
Notes: The figures in red (blue) letters indicate that the values of the variables increase (decrease) with the shocks.

The aggregate output increases by 5.2% when the glass ceiling disappears (Column (2)). It is lower than that in Table 5. This is due to higher managerial skill of females in the service sector ( $B_f^1$ ) and high service sector share of female labour force ( $\alpha_f$ ). Figure 7 shows cumulative distributions of managerial skill in both models. It shows that female managerial skill in the service sector is higher than that in the manufacturing sector. The service sector share of female employment determines the number of female managers in the service sector. Due to its high percentage, the increase in the number of female managers in the service sector is higher than that in the manufacturing sector. A large number of new women managers with high managerial skills in the service sector create a large demand for labour. Therefore, the cutoffs for equilibrium wage and managerial skill incline rapidly and the number of managers cannot increase as much as in a one-sector model. Although women can accumulate as much managerial skill as men, the aggregate output in a two-sector model cannot reach that of a one-sector model. In other words, the increase in aggregate output in a one-sector model may be overestimated.

When the labour force participation rates of women equal that of men (Column (3)), the aggregate output increases by 13.2%. The aggregate output increases by 18.9% when the gender wage gaps disappear and labour force participation rates of women equal that of men (Column (4)).

Figure 7 Cumulative distributions of managerial skill in both models

A. A one-sector model



A. A two-sector model

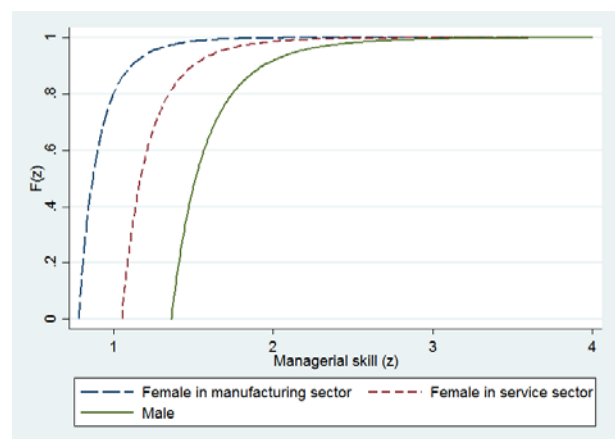
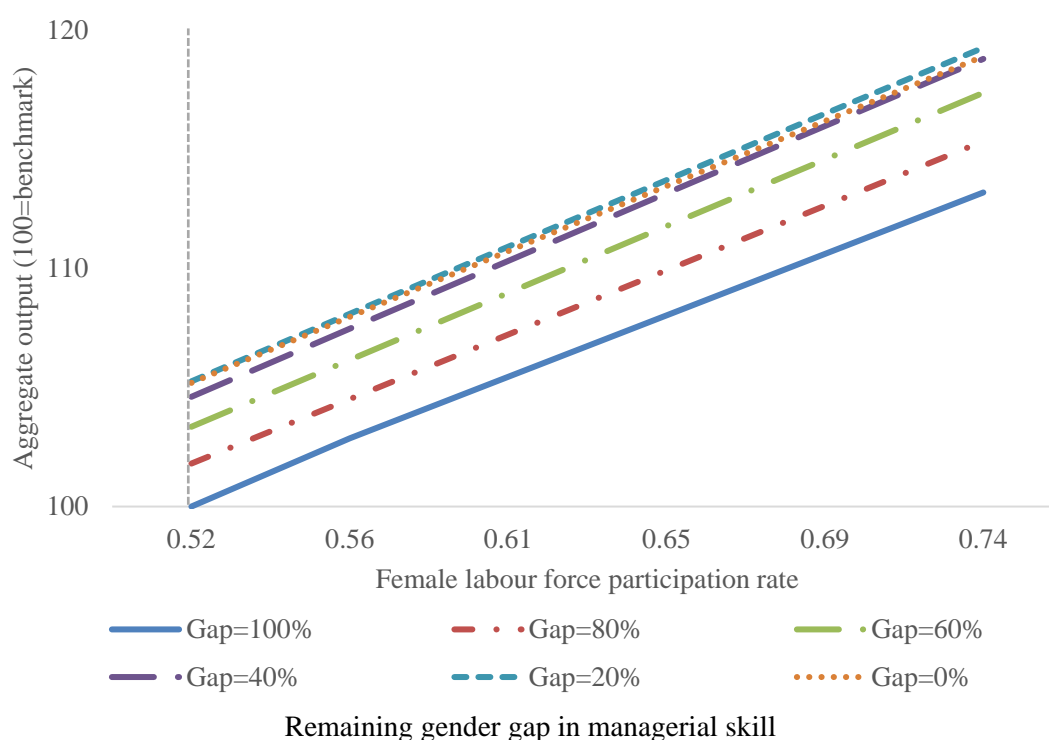


Figure 8 is calculated as shown in Figure 6. The narrowing gender gap in the labour force participation rate is more effective in increasing aggregate output. Unlike the results of a one-sector model, the output gain from the removal of the glass ceiling is non-monotonic as per given parameters. The aggregate output decreases when the gender gap in managerial skill remains below 20%. This explanation aligns with that of the figures in Column (2) of Table 8. The equilibrium wage and managerial skill cutoffs incline rapidly due to large labour demand created by new women managers with high managerial skills in the service sector. Therefore, the number of workers decreases until the gender gap in managerial skill remains at 20%, only then do the number of workers increase. This increase is greater in the service sector than in the manufacturing sector, as the former has a smaller gender difference in managerial skill. It holds in cases of no gender wage gap or productivity gap between the service and manufacturing sectors.

Figure 8 Effects of narrowing gender gap in managerial skill and labour force participation rate on aggregate output



Note: The intersection point of the grey dotted line and the x-axis is the benchmark estimate of aggregate output.

Figure 8 implies that the effectiveness of glass ceiling policies will diminish with their implementation. It also implies that an optimal glass ceiling might exist to maximise aggregate output. If the service sector share of female employment reduces, the removal of the glass ceiling becomes monotonic. The additional simulation results suggest that the effects of policies in removing the glass ceiling on output will become monotonic if the government introduces policies to reallocate female employment from the service sector to the manufacturing sector.

## **V. Conclusion**

This study constructs and calibrates a macroeconomic model that explains Korea's glass ceiling and examines the output cost of gender discrimination. I investigate gender discrimination in the Korean labour market using microdata. Women in the Korean labour market have lower wages in the same positions as men. Women may have less managerial skill, as they are unable to accumulate as much managerial skill as men. The glass ceiling is more serious in the manufacturing sector in comparison to the service sector. Fortunately, the glass ceiling in the Korean labour market is improving gradually.

The numerical results suggest that the disappearance of gender discrimination in the Korean labour market will promote economic output. In a one-sector model, the aggregate output increases by 7.2% when the glass ceiling disappears. The output gain from the removal of the glass ceiling is monotonic because the number of workers continues to decline and the number of managers continues to increase gradually.

An extended two-sector model shows results that are more accurate, as a one-sector model cannot reflect that the productivity of the manufacturing sector is greater than that of the service

sector; however, the glass ceiling is more prevalent in the manufacturing sector than in the service sector. In a two-sector model, the aggregate output increases by 5.2% when the glass ceiling disappears. Unlike a one-sector model, the output gain from removing the glass ceiling is non-monotonic because wages increase rapidly due to high labour demand and the number of workers increase beyond at a certain level as per given parameters. A two-sector model implies that an optimal glass ceiling might exist to maximise aggregate output.

The Korean government is taking the problem of glass ceiling in the economy seriously and implementing various policies. The Ministry of Employment and Labour has established the 'Specialized Committee on Affirmative Action' to address gender discrimination and promote gender equality in employment. The target groups for this affirmative action are firms with more than 500 employees. The committee provides consulting services to poorly performing companies. The Ministry of Gender Equality and Family has set up a 'women leaders academy' and 'women leaders database' to better utilise female human resources. They also expand female participation in government committees and the number of female officials in the public sector. They also encourage enterprises to set a female manager ratio target, train female managers, create a family friendly workplace, and develop career development programs.

This study provides important policy implications by demonstrating the effect of various gender policies on actual outputs, using macroeconomic models adapted to the Korean context. The glass ceiling may disappear by implementing government policies designed by the Ministry of Gender Equality and Family. Furthermore, the additional simulation results suggest that the effects of the policies in removing the glass ceiling will become monotonic if the government introduces policies to reallocate female employment from the service sector to the manufacturing sector.

The model also has some limitations. The simulated aggregate output estimates may be underestimated because the disappearing gender discrimination affects some parameters. In addition, I did not analyse the transition dynamics of output when gender discrimination disappears.

Furthermore, the model excludes household production and childbearing decisions of women. I plan to pursue further research, which includes these limitations.

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