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Abstract

This study measures gender disparity in the structure of educational attainment using the Barro and Lee dataset on educational attainment for Asian countries and regions over the period 1950-2015. To achieve this objective, it develops a Gini decomposition method of educational attainment based on grouped data. The study conducts a Gini decomposition analysis of educational attainment by gender. A panel data regression analysis reveals that the gender disparity in educational attainment seems to follow a slight U-shaped pattern with respect to the expansion of education, implying that the gender disparity in educational attainment first declines, but after reaching a lowest point at the mean number of years of education of around 10, it may begin to increase with the further expansion of education.

JEL code: I2; O1
Key words: gender disparity in education, decomposition of education Gini by gender, grouped data on educational attainment, panel data regression analysis, Asia

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1. Introduction

Barro and Lee (2013) compiled a dataset on educational attainment at five-year intervals from 1950 to 2015. The dataset provides the proportions of individuals aged 25 to 65 for females and males across seven levels of education: (0) no formal education, (1) incomplete primary, (2) complete primary, (3) lower secondary, (4) upper secondary, (5) incomplete tertiary, and (6) complete tertiary education. The objective of this study is to examine gender disparity in the structure of educational attainment based on the Barro and Lee dataset for Asian countries and regions over the period 1950-2015. To achieve this objective, the study conducts a decomposition analysis of educational inequality by gender. We focus on Asia because the countries and regions in this area share similar socio-economic characteristics.

Since Thomas, et al. (2001) introduced the Gini coefficient of education as an extension of the Gini coefficient of income distribution, many researchers have employed the Gini coefficient to measure educational inequality (Castello and Domenech, 2002; Lin, 2007; Lim and Tang, 2008; Hojo, 2009; Fordvari and van Leeuwen, 2011; Agrawal, 2014; Meschi and Scervini, 2014; Coady and Dizioli, 2018; Lee and Lee, 2018; Banzragch, et al., 2019; Shukla and Mishra, 2019; Castello-Climent and Domenech, 2021; Almeida, et al., 2022; and Luo, et al., 2022; Akita, 2023). Because individuals without formal education are usually assigned 0 years, it is not possible to employ the Theil indices to measure educational inequality, though they are additively decomposable by population subgroups, that is, expressed as the sum of the within-group and between-group inequality components (Bourguignon, 1979; Shorrocks, 1980; and Anand, 1983).

Bhattacharya and Mahalanobis (1967) and Pyatt (1976) developed a decomposition method of the Gini coefficient. Unlike the Theil indices, the Gini coefficient cannot usually be expressed as the sum of the within-group and between-group inequality components; the residual component emerges if there are distributional overlaps between population subgroups. Lambert and Aronson (1993) presented a graphical interpretation of the residual component based on the Lorenz diagram. These studies, however, developed and examined the Gini decomposition method based on individual-level or household-level data. The Barro-Lee dataset provides grouped data on educational attainment. Therefore, this present study first develops a Gini decomposition method of educational attainment based on grouped data. It

then conducts a Gini decomposition analysis to examine gender disparity in the structure of educational attainment for Asian countries and regions over the period 1950-2015.

2. Decomposition of the education Gini coefficient by gender based on grouped data

Consider a country with aforementioned seven levels of education. If we let e_h and q_h be the cumulative number of years of education for the *h*th level of education and the proportion of individuals with *h*th level of education, respectively, then, the Gini coefficient of education is defined by

$$G = \frac{1}{2\mu}\sum_{h=0}^{6}\sum_{k=0}^{6} q_h q_k |e_k - e_h| \,, \tag{1}$$

where $\mu = \sum_{h=0}^{6} q_h e_h$ is the mean years of education and $\sum_{h=0}^{6} q_h = 1$ (Thomas, et al., 2001). Since $0 \le e_0 < e_1 < \cdots < e_6$, we can rewrite this equation as follows.

$$G = \frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6} q_h q_k (e_k - e_h). \tag{2}$$

Next we let p_{1h} be the proportion of females with *h*th level of education and p_{2h} the proportion of males with *h*th level of education. Then, the Gini coefficient of education for females is given by

$$G_1 = \frac{1}{\mu_1}\sum_{h=0}^{6}\sum_{k>h}^{6} p_{1h} p_{1k} (e_k - e_h), \tag{3}$$

while the Gini coefficient of education for males is given by

$$G_2 = \frac{1}{\mu_2}\sum_{h=0}^{6}\sum_{k>h}^{6} p_{2h} p_{2k} (e_k - e_h), \tag{4}$$

where $\mu_1 = \sum_{h=0}^{6} p_{1h} e_h$ and $\mu_2 = \sum_{h=0}^{6} p_{2h} e_h$ are the mean years of education for females and males, respectively and we have $\sum_{h=0}^{6} p_{1h} = 1$ and $\sum_{h=0}^{6} p_{2h} = 1$.

If we let s_1 and s_2 be the shares of females and males in total population, respectively, then we have the following relationship.

$$q_h = \sum_{i=1}^{2} s_i p_{ih} = s_1 p_{1h} + s_2 p_{2h}, \text{ where } \sum_{i=1}^{2} s_i = 1. \tag{5}$$

Substituting Equation (5) into Equation (2), we can modify overall education Gini coefficient as follows.

$$\begin{aligned} G &= \frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6} q_h q_k (e_k - e_h) \\ &= \frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6} (s_1 p_{1h} + s_2 p_{2h})(s_1 p_{1k} + s_2 p_{2k})(e_k - e_h) \\ &= \frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6} (s_1 p_{1h})(s_1 p_{1k})(e_k - e_h) + \frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6} (s_2 p_{2h})(s_2 p_{2k})(e_k - e_h) \\ &\quad + \frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6} (s_1 p_{1h})(s_2 p_{2k})(e_k - e_h) + \frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6} (s_2 p_{2h})(s_1 p_{1k})(e_k - e_h). \end{aligned} \tag{6}$$

We can now obtain the following proposition.

Proposition 1

If there is no overlap between the female and male groups in the distribution of educational attainment, we have

$$G = G_{WG} + G_{BG},$$

where G_{WG} is the within-group Gini component, while G_{BG} is the between-group Gini component. If we let v_1 and v_2 be the shares of the female and male groups in total number of years of education, respectively, then we have

$$G_{WG} = \sum_{i=1}^{2} s_i v_i G_i, \text{ where } \sum_{i=1}^{2} v_i = 1, \text{ and}$$

$$G_{BG} = \frac{1}{2\mu}\sum_{i=1}^{2}\sum_{j=1}^{2} s_i s_j \left|\mu_i - \mu_j\right|. \quad (7)$$

Proof

Because we have $v_i = \frac{s_i\mu_i}{\sum_{i=1}^{2} s_i\mu_i} = \frac{s_i\mu_i}{\mu}$ by definition, the first term of Equation (6) can be modified to

$$\frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6}(s_1 p_{1h})(s_1 p_{1k})(e_k - e_h)$$
$$= s_1\left(\frac{s_1\mu_1}{\mu}\right)\left(\frac{1}{\mu_1}\sum_{h=0}^{6}\sum_{k>h}^{6} p_{1h}p_{1k}(e_k - e_h)\right)$$
$$= s_1 v_1 G_1.$$

Similarly, the second term of Equation (6) can be modified to

$$\frac{1}{\mu}\sum_{h=0}^{6}\sum_{k>h}^{6}(s_2 p_{2h})(s_2 p_{2k})(e_k - e_h)$$
$$= s_2 v_2 G_2.$$

Adding the first two terms of Equation (6), we obtain

$$G_{WG} = \sum_{i=1}^{2} s_i v_i G_i,$$

which is the within-group Gini component. This is the weighted sum of education Gini for females and education Gini for males, because $\sum_{i=1}^{2} s_i v_i$ does not usually equal to one. Suppose next that there is no overlap between the female and male groups in the distribution of educational attainment. We can safely assume that in the female group, $p_{1h} = 0$ for $m + 1 \leq h \leq 6$, while in the male group, $p_{2h} = 0$ for $0 \leq h \leq m$. Then, the third term of Equation (6) can be modified as follows.

$$\frac{s_1 s_2}{\mu}\sum_{h=0}^{6} p_{1h}\sum_{k>h}^{6} p_{2k}(e_k - e_h)$$
$$= \frac{s_1 s_2}{\mu}\sum_{h=0}^{m} p_{1h}\sum_{k>h}^{6} p_{2k}(e_k - e_h) \text{ since } p_{1h} = 0 \text{ for } m + 1 \leq h \leq 6$$

$$= \frac{s_1 s_2}{\mu} \sum_{h=0}^{m} p_{1h} \left(\sum_{k=m+1}^{6} p_{2k} e_k - e_h \sum_{k=m+1}^{6} p_{2k} \right) \text{ since } p_{2h} = 0 \text{ for } 0 \le h \le m$$

$$= \frac{s_1 s_2}{\mu} \left(\sum_{k=m+1}^{6} p_{2k} e_k - \sum_{h=0}^{m} p_{1h} e_h \right) \text{ since } \sum_{h=0}^{m} p_{1h} = 1 \text{ and } \sum_{k=m+1}^{6} p_{2k} = 1$$

$$= \frac{s_1 s_2}{\mu} \left(\sum_{k=0}^{6} p_{2k} e_k - \sum_{h=0}^{6} p_{1h} e_h \right)$$

$$= \frac{s_1 s_2}{\mu} (\mu_2 - \mu_1).$$

On the other hand, the fourth term of Equation (6) is modified to

$$\frac{s_1 s_2}{\mu} \sum_{h=0}^{6} p_{2h} \sum_{k>h}^{6} p_{1k} (e_k - e_h)$$

$$= \frac{s_1 s_2}{\mu} \sum_{h=m+1}^{6} p_{2h} \sum_{k>h}^{6} p_{1k} (e_k - e_h) \text{ since } p_{2h} = 0 \text{ for } 0 \le h \le m$$

$$= 0 \text{ since } p_{1k} = 0 \text{ for } m + 1 \le k \le 6.$$

Therefore, the sum of the third and fourth terms of Equation (6) is reduced to

$$\frac{s_1 s_2}{\mu} (\mu_2 - \mu_1) + 0$$

$$= \frac{1}{\mu} \sum_{i=1}^{2} \sum_{j>i}^{2} s_i s_j \left(\mu_j - \mu_i \right),$$

$$= \frac{1}{2\mu} \sum_{i=1}^{2} \sum_{j=1}^{2} s_i s_j \left| \mu_i - \mu_j \right| > 0,$$

which is the between-group Gini component (G_{BG}). In conclusion, we have

$$G = G_{WG} + G_{BG}.$$

Proposition 1 implies that when there are overlaps between the female and male groups in the distribution of educational attainment, overall education Gini coefficient can be decomposed by gender as follows.

$$G = G_{WG} + G_{BG} + G_R, \tag{8}$$

where $G_R > 0$ is the residual component, which assesses the extent of overlaps between the female and male groups in the distribution of educational attainment. The residual component can be obtained by subtracting $G_{WG} + G_{BG}$ from overall education Gini coefficient.

3. Measuring gender disparity in the structure of educational attainment for Asian countries and regions

Based on the Barro and Lee dataset on educational attainment for the population aged 25 to 65, we measure gender disparity in the structure of educational attainment for Asian countries and regions over the period 1950-2015. Table 1 provides a list of these Asian countries and regions.

Table 1. Mean years of education and education Gini coefficient for Asian countries and regions in 2015

		Mean years of education				Education Gini coefficient			
Country/region	WB code	Male	Female	Total	M/F ratio	Male	Female	Total	M/F ratio
Afghanistan	AFG	5.8	1.4	3.7	4.03	0.56	0.87	0.71	0.64
Bangladesh	BGD	6.9	5.7	6.3	1.21	0.46	0.51	0.49	0.90
Brunei Darussalam	BRN	8.5	8.6	8.6	0.98	0.31	0.32	0.32	0.97
Cambodia	KHM	4.6	3.0	3.8	1.57	0.49	0.50	0.50	0.98
China	CHN	9.3	8.6	9.0	1.09	0.16	0.21	0.18	0.77
China, Hong Kong	HKG	11.7	11.3	11.5	1.04	0.18	0.20	0.19	0.92
China, Macao	MAC	10.8	10.7	10.7	1.00	0.20	0.21	0.20	0.96
Fiji	FJI	9.1	9.5	9.3	0.96	0.21	0.19	0.20	1.13
India	IND	8.6	5.3	7.0	1.62	0.32	0.57	0.44	0.57
Indonesia	IDN	8.6	7.9	8.3	1.09	0.27	0.31	0.29	0.87
Japan	JPN	12.8	13.2	13.0	0.97	0.14	0.07	0.11	1.90
Kazakhstan	KAZ	12.4	12.7	12.5	0.98	0.07	0.07	0.07	0.97
Kyrgyzstan	KGZ	12.3	12.4	12.4	0.99	0.06	0.07	0.06	0.95
Lao	LAO	7.9	6.1	7.0	1.31	0.34	0.46	0.40	0.75
Malaysia	MYS	10.5	10.5	10.5	1.00	0.19	0.21	0.20	0.91
Maldives	MDV	6.6	6.0	6.4	1.09	0.34	0.38	0.35	0.89
Mongolia	MNG	11.0	12.0	11.5	0.92	0.18	0.15	0.17	1.20
Myanmar	MMR	5.3	5.9	5.6	0.91	0.39	0.44	0.43	0.90
Nepal	NPL	6.2	4.0	4.9	1.58	0.44	0.63	0.55	0.69
Pakistan	PAK	6.9	4.2	5.6	1.65	0.46	0.67	0.56	0.68
Papua New Guinea	PNG	5.2	3.7	4.5	1.38	0.36	0.52	0.44	0.69
Philippines	PHL	9.7	10.6	10.1	0.92	0.24	0.20	0.22	1.19
Republic of Korea	KOR	13.2	12.5	12.8	1.06	0.11	0.14	0.12	0.79
Singapore	SGP	12.9	12.6	12.8	1.02	0.14	0.15	0.15	0.94
Sri Lanka	LKA	10.2	10.3	10.3	0.99	0.15	0.14	0.14	1.01
Taiwan	TWN	12.3	12.2	12.2	1.01	0.10	0.13	0.11	0.81
Tajikistan	TJK	12.3	11.6	11.9	1.07	0.10	0.10	0.11	1.00
Thailand	THA	8.1	7.8	7.9	1.04	0.33	0.37	0.35	0.91
Tonga	TON	10.4	10.8	10.6	0.97	0.09	0.08	0.09	1.18
Viet Nam	VNM	8.7	8.0	8.3	1.09	0.24	0.28	0.26	0.87

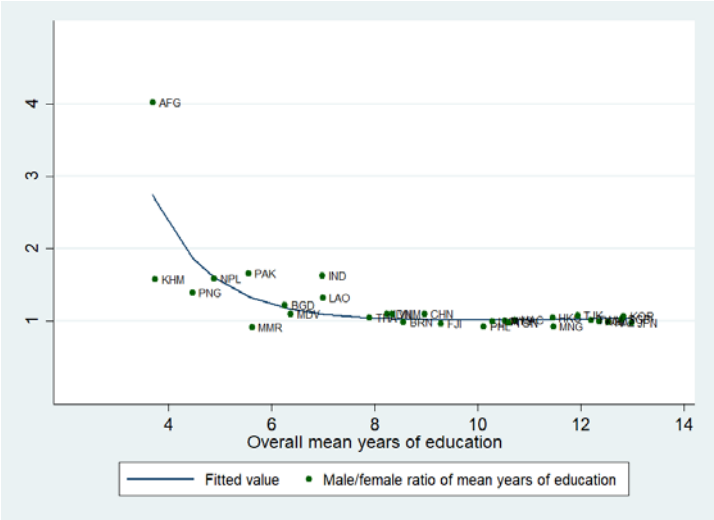
(Notes) WB code: World Bank country code. M/F ratio: male-to-female ratio.
(Source) Barro and Lee dataset on educational attainment (Barro and Lee, 2013).

Table 1 also presents the mean years of education and the education Gini coefficient for males and females in 2015. To estimate the mean years of education and the education Gini coefficient, 0, 3, 6, 9, 12, 14, and 16 years are assigned to the seven education levels described above.[1] The key observations from this table are summarized as follows. First, in most Asian countries and regions, the male group has larger mean years of education than the female group. Second, the male-to-female ratio of mean years of education decreases as the overall mean years of education increase; however, it stabilizes around one once the overall mean years of education exceed eight (Figure 1). Third, in most Asian countries and regions, the male group

[1] Each country has a different duration for each level of education. However, for simplicity, we assume that all the selected Asian countries have the same duration at each level of education.

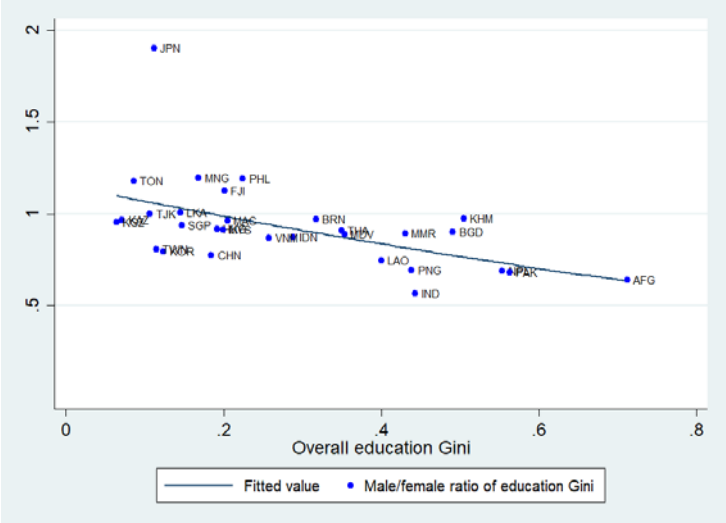
has a smaller Gini than the female group. Fourth, the male-to-female ratio of education Gini declines as the overall education Gini increases (Figure 2).

Figure 1. The male-to-female ratio of mean years of education against the overall mean years of education in 2015



(Source) Barro and Lee dataset on educational attainment (Barro and Lee, 2013).

Figure 2. The male-to-female ratio of education Gini against the overall education Gini in 2015

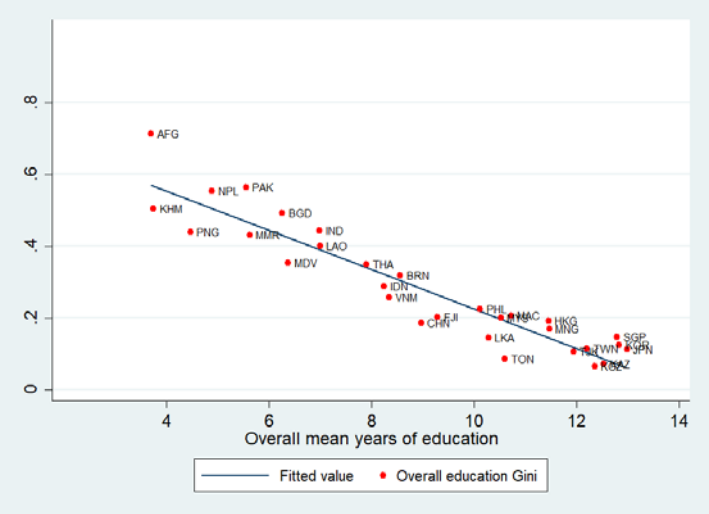


(Source) Same as Figure 1.

We should note that since the education Gini is positively correlated with the proportion of individuals without formal education, it is highly likely that the education Gini is negatively correlated with the mean years of education (Castello-Climent and Domenech, 2021; Akita,

2023). Figure 3 shows a significant negative relationship between the education Gini and the mean years of education (R-squared = 0.88). Since the male group typically has a higher mean number of years of education than the female group, it is likely that the former has a lower education Gini than the latter.

Figure 3. Overall education Gini against overall mean years of education in 2015



(Source) Same as Figure 1.

Table 2 presents the result of the decomposition of the education Gini coefficient by gender in 2015. The key observations from this table are summarized below.

Table 2. Decomposition of education Gini coefficient by gender for Asian countries and regions in 2015

Country/region	Education Gini				Education Gini (contribution in %)		
	W-group	B-group	Residual	Total	W-group	B-group	Residual
Afghanistan	0.31	0.29	0.10	0.71	44.2	41.2	14.6
Bangladesh	0.24	0.05	0.20	0.49	49.6	9.8	40.6
Brunei Darussalam	0.16	0.00	0.15	0.32	50.0	1.4	48.6
Cambodia	0.24	0.11	0.15	0.50	48.3	22.1	29.6
China	0.09	0.02	0.07	0.18	49.5	11.5	39.0
China, Hong Kong	0.10	0.01	0.09	0.19	50.7	4.6	44.7
China, Macao	0.10	0.00	0.10	0.20	50.2	0.5	49.2
Fiji	0.10	0.01	0.09	0.20	49.9	5.3	44.8
India	0.21	0.12	0.12	0.44	46.7	26.4	26.9
Indonesia	0.14	0.02	0.12	0.29	49.8	7.6	42.7
Japan	0.05	0.01	0.05	0.11	48.9	7.7	43.4
Kazakhstan	0.04	0.01	0.03	0.07	50.0	7.5	42.5
Kyrgyzstan	0.03	0.00	0.03	0.06	50.0	4.9	45.1
Lao	0.20	0.07	0.14	0.40	48.9	16.9	34.3
Malaysia	0.10	0.00	0.10	0.20	49.9	0.3	49.7
Maldives	0.19	0.02	0.15	0.35	53.1	5.4	41.5
Mongolia	0.08	0.02	0.06	0.17	49.4	12.7	37.9
Myanmar	0.21	0.02	0.19	0.43	49.2	5.6	45.2
Nepal	0.27	0.11	0.17	0.55	49.1	20.4	30.5
Pakistan	0.27	0.12	0.17	0.56	47.8	21.6	30.6
Papua New Guinea	0.21	0.08	0.15	0.44	48.5	18.4	33.1
Philippines	0.11	0.02	0.09	0.22	49.6	9.8	40.5
Republic of Korea	0.06	0.01	0.05	0.12	49.6	11.7	38.7
Singapore	0.07	0.01	0.07	0.15	50.1	3.6	46.3
Sri Lanka	0.07	0.00	0.07	0.14	50.1	1.9	48.1
Taiwan	0.06	0.00	0.06	0.11	49.9	1.7	48.4
Tajikistan	0.05	0.02	0.04	0.11	49.1	14.9	36.0
Thailand	0.17	0.01	0.16	0.35	50.0	2.8	47.2
Tonga	0.04	0.01	0.03	0.09	49.8	9.5	40.7
Viet Nam	0.13	0.02	0.11	0.26	49.8	7.9	42.3

(Source) Same as Table 1.

First, the within-group education Gini component is a predominant determinant by accounting for 45-50% of overall education Gini coefficient. The remainder is divided between the between-group education Gini and the residual education Gini. Second, there seems to be a slight U-shaped relationship between the between-group education Gini coefficient and the overall mean years of education. To formerly test whether this relationship holds for a sample of Asian countries and regions over the period 1950–2015, we perform a panel data regression analysis. Table 3 presents the result of this analysis, while Figure 4 shows a scatter plot for this relationship across Asian countries and region over the period 1950-2015. Table 3 also presents the result of a pooled OLS regression analysis (column 1).

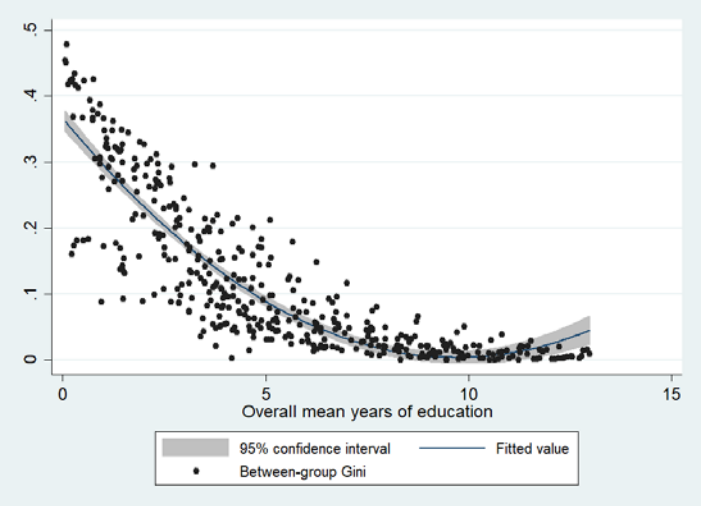
Table 3. A panel data regression analysis for the relationship between the between-group education Gini and overall mean years of education

Dependent variable = between-group education Gini coefficient

Independent variables	Pooled OLS		Fixed effects		Random effects			
	(1)		(2)		(3)		(4)	
Mean years of education	-0.0747	***	-0.0516	***	-0.0622	***	-0.0573	***
	(0.0037)		(0.0112)		(0.0069)		(0.0096)	
Mean years of education squared	0.0038	***	0.0027	***	0.0030	***	0.0029	***
	(0.0003)		(0.0005)		(0.0004)		(0.0005)	
Constant	0.3665	***	0.3079	***	0.3332	***	0.3195	***
	(0.01179		(0.0284)		(0.0261)		(0.0307)	
Time specific effects	No		Yes		No		Yes	
No. of observations	420		420		420		420	
R-squared	0.780							
Within			0.819		0.811		0.817	
Between			0.785		0.772		0.780	
Overall			0.748		0.777		0.768	
Mean years of education (at lowest Gini)	9.70		9.51		10.35		9.85	
Hausman test								
Chi-squared			9.37					
p-value			0.8572					

(Notes) *** $p < 0.01$. Values in parenthesis are robust standard error.
(Source) Same as Table 1.

Figure 4. Between-group education Gini against overall mean years of education for Asian countries and regions over the period 1950-2015



(Source) Same as Figure 1.

Column 2 presents the result based on the fixed effects model, while columns 3 and 4 display the result based on the random effects model (column 3 without time specific effects; column 4 with time specific effects). According to the Hausman specification test, the Chi-squared value is 9.37 with a *p*-value of 0.857; thus, we cannot reject the null hypothesis that the individual effects are strictly uncorrelated with the independent variables. Therefore, the random effects model is preferred over the fix effects model.

The coefficients for the mean years of education and the squared mean years of education are statistically significant at the 1% level of significance. As expected, they are negative and positive, respectively, indicating that gender disparity in educational attainment, as measured by the between-group education Gini, first declines. However, after reaching its lowest point at the mean number of years of education of around 10, it may begin to increase with further educational expansion. This suggests that the expansion of higher education could have differential impacts on the educational attainment of males and females.

4. Conclusion

This study measured gender disparity in the structure of educational attainment using the Barro and Lee dataset on educational attainment for Asian countries and regions over the period 1950-2015. To achieve this objective, it developed a Gini decomposition method of educational attainment based on grouped data and conducted a Gini decomposition analysis of educational attainment by gender.

Major findings are summarized as follows. First, in most Asian countries and regions, the male group has larger mean years of education than the female group. The male-to-female ratio of mean years of education decreases as the overall mean years of education increase; however, it stabilizes around one once the overall mean years of education exceed eight. Second, in most Asian countries and regions, the male group has a smaller Gini than the female group. The male-to-female ratio of education Gini declines as the overall education Gini increases.

Third, according to the Gini decomposition analysis of educational attainment by gender, the within-group education Gini component is a predominant determinant, by accounting for 45-50% of overall education Gini coefficient. The remainder is divided between the between-group education Gini and the residual education Gini. Fourth, the panel data regression analysis for a sample of Asian countries and regions over the period 1950-2015 revealed that there seems to be a slight U-shaped relationship between the between-group education Gini and the overall mean years of education. This means that gender disparity in educational attainment first declines with educational expansion. However, after reaching its lowest point at the mean number of years of education of around 10, it may begin to increase with further educational expansion. This suggests that the expansion of higher education could have differential impacts on the educational attainment of males and females. To address the

increasing gender disparity in the later stages of educational expansion, it is essential to ensure equitable access to higher education. This, in turn, could help mitigate rising income inequality.

This study is preliminary as it focuses on Asian countries and regions. In future research, we aim to examine gender disparity in the structure of educational attainment using a much larger sample. This study considers that education and human capital are synonymous. However, they are distinct concepts; the number of years of education is typically translated into human capital by applying the returns to education at each level of education. In future research, we plan to explore gender disparity in human capital.

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