한국경제학보 제16권 제2호
The Korean Journal of Economics Vol. 16, No. 2(Autumn 2009)

Peer Characteristics and the Effectiveness of Single-Sex Schooling

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Abstracts

Single-sex schools have been suggested as an alternative to failing traditional public schools on the grounds that they provide a more favorable learning environment. However, estimated gains to academic achievement from single-sex schooling are generally confounded by selection bias since single-sex schools tend to attract different students than mainstream schools in most countries. This paper examines the difference in academic achievement between students in single-sex and coeducational schools across countries. The results suggest that single-sex schooling does not always have a positive influence on student achievement and that the selection process often explains a significant proportion of the observed achievement gap between single-sex and coeducational schools.

KRF Classification : B030400
Keywords : Peer effect, Academic achievement, School choice

Ⅰ. Introduction

More than two decades, U.S. public schools have been barred from separating boys and girls in different classrooms. In recent years, however, this policy intended to promote gender equity in

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education and to prohibit discrimination on the basis of sex has been challenged by new regulations and programs that attempt to provide considerable flexibility in establishing single-sex classes in public schools (Mead 2003; Salomone 2006). These changes have brought on a resurgence of debate on single-sex teaching in public schools (Kaminer 1998; Sax 2001; Sadker and Zittleman 2004).

Coeducation has been a standard practice for most public schools in North American countries as well as in many Western European countries for decades. One of the main arguments favoring coeducation is that coeducational schools prepare students for life beyond school by providing a more realistic and natural social environment (Schneider and Coutts 1982; Hannan et al. 1996; Robinson and Smithers 1999). For example, a recent survey reports that students in coeducational schools feel more confident expressing their views in the presence of opposite sex students (Strategic counsel 2006). Some studies also suggest that coeducation provides a fairer and more desirable educational environment to students (Tyack and Hansot 1992) because the coeducational setting tends to reduce sex-stereotypes (Harris 1986 Spielhofer, Benton, and Schagen 2004) and improve gender equity in terms of school resources and curriculum (Kenway and Willis 1986).

However, coeducational schools are seldom seen as a more effective option to help students to succeed academically. Also there have been growing concerns about gender inequity in coeducational classrooms. A series of studies published during 1990s triggered heated debates on gender bias against female students in coeducational classrooms. These studies argue that girls are unable to reach their fullest potential in coeducational schools because they receive less teacher attentions than boys (Sadker and Sadker 1994), lose confidence and interest in math and science (AAUW 1992, 1998, 2000), and experience the threat of sexual

harassment in school. Some other researchers focus more on considerable underachievement of male students in coeducational classrooms (Pollack 1998 Sommers 2000) and argue that boys in coeducational classrooms are negatively affected by the reform movements to improve the outcomes of schooling for girls (Gipps 1996; Yates 1997). Some studies report that male students in coeducational classrooms substantially lag behind in language subjects (Kleinfeld 1999), experience more behavioral problems in school (Gilbert and Gilbert 1998), and are more likely to drop out of schools and more likely to be incarcerated (Leake and Leake 1992).

Responding to calls for the improvement in education more generally, or to gender equity concerns, single-sex education has been suggested as an alternative to failing traditional public schools and as an expansion of educational opportunities for boys and girls. Much literature has suggested that single-sex schooling benefits students by improving their academic achievement (Riordan 1985; Lee and Bryk 1986; Lee and Marks 1990; LePore and Warren 1997; Vezeau, Bouffard, and Chouinard 2000; Warrington and Younger 2001; Hoffman, Badgett, and Parket 2008) and self-perceptions, particularly for females (Granleese and Joseph 1993; Frehill 1997; Watson, Quatman, and Edler 2002; Thompson 2003). In particular, supporters of single-sex education emphasize potential benefits for a subset of boys and girls: boys who are from disadvantaged family backgrounds (Hamilton 1986; Whitehead 1994 Baker 2002) and girls who lag behind in subjects such as math and science (Cairns 1990; Moor, Piper, and Schaeffer 1993 Colley et al. 1994).

Evidence regarding the impact of single-sex education has not been always conclusive and unequivocal in many aspects (Jackson and Smith 2000; Datnow, Hubbard and Conchas 2001; Campbell

and Sanders 2002; Herr and Arms 2004; Hubbard and Datnow 2005). Some studies find evidence of a negative impact of single-sex education on boys' academic achievement (Martino and Meyenn 2002; Rowan et al. 2002; Van De Gaer et al. 2004). Some researchers also argue that single-sex schools may promote stereotypical attitudes toward the opposite sex by reinforcing sex role stereotypes in a single-sex setting (Brutsaert and Bracke 1994; Ball and Gewirtz 1997). For example, studies report that female students attending single-sex schools exhibit greater body dissatisfaction and eating disorder (Mesinger 2001) and that single-sex schooling can exacerbate the problematic behaviors among boys (Jackson 2002; Warrington and Younger 2003).

Despite much debate over potential gains on academic achievement from single-sex schooling, coeducational schooling is a more dominant form of public education in most countries. Single-sex schools tend to be specialized religious schools, privately funded schools, or magnet schools. In addition to offering a different learning environment, these specialized schools also tend to attract students from specific parts of the socioeconomic and/or religious spectrum. For example, students from higher socioeconomic backgrounds are more likely to apply to prestigious private schools, students from Catholic or Muslim families are more likely to apply to religious schools and students with special talents are more likely to apply to magnet schools. As many studies have suggested, it is possible that differences in academic achievement levels between single-sex and coeducational schools could be the result of a special educational setting that separates boys and girls in different classrooms (Swan 1998; Sukhnandan et al. 2000). However, considering the selection process for different types of secondary schools, the observed achievement gap may be associated with pre-enrollment differences in student characteristics

between single-sex and coeducational schools (Marsh 1989, 1991). Yet, previous studies have not been able to adequately control for the substantial differences in student characteristics across single-sex and coeducational schools. The current study addresses this gap in the literature by focusing on the relationship between student characteristics prior to enrollment and its possible role in school achievement.

Using international data on student achievement, this study explores the possible correlation between the effectiveness of single-sex schooling and the potential pre-enrollment differences in student and peer characteristics in 10 countries. This paper tests a cross-national hypothesis: school selectivity and parental school selection will explain at least some of the observed academic achievement differences between single-sex and coeducational schools. First, I measure the impact of single-sex schooling with a basic set of socioeconomic control and compare the magnitude of the coefficients across countries with varying degree of single-sex schooling. If the proportion of single-sex schools is small and the demand for single-sex schools overlaps the demand for specialized schools, we can expect significant academic advantages (or disadvantages) for single-sex school students who choose to go to such specialized schools. If single-sex schools are a part of mainstream schools and students are randomly assigned to either single-sex or coeducational schools, little difference in academic achievement can be expected between students in single-sex and coeducational schools.

Second, I measure the impact of single-sex schooling with school selectivity and peer characteristics controls. School selectivity and peer characteristics could serve as good indicators for potential pre-existing differences in student ability and socioeconomic backgrounds between single-sex and coeducational schools.

Suppose that single-sex schools apply more rigorous entrance standards when admitting students. For instance, Singaporean single-sex schools are well-known for their requirements for stronger academic records and higher test scores from the "Primary School Leaving Examination (PSLE),"a national examination taken by all students in Singapore near the end of their sixth year in primary school. Students who had good academic records before entering single-sex schools are more likely to achieve higher test scores after entering single-sex schools. School selectivity variables in the model may capture potential pre-existing difference in student ability. In countries where more school choices are available, parents tend to put more effort to find which school best meets their own child's education needs and there will be more sorting based on ability and socioeconomic backgrounds (Urquiola 2005; Bohlmark and Lindahl 2007). Since students enrolled in specialized schools are more likely from similar socioeconomic backgrounds, peer characteristic variables can serve as good indicators for parental selection toward single-sex schools.

If single-sex classes are a part of specialized schools with special entrance standards, students in single-sex schools may represent a more academically and socially advantaged group and we can expect substantial differences between two measures of the impact of single-sex schooling with and without selectivity controls. This paper examines whether school selectivity and differences in peer group characteristics explain at least some of the test score differences across the two types of schools. The results of this study suggest that single-sex schools do not always have a positive influence on student achievement, and that the selection process explains a significant proportion of the observed score gap between single-sex and coeducational schools.

Ⅱ. Data: TIMSS

In order to examine the effectiveness of single-sex schooling under different education systems, this paper uses the Trends in International Mathematics and Science Study (TIMSS), an international study of student achievement in math and science. TIMSS assesses math and science achievement of eighth graders from 63 participating countries. TIMSS also surveyed students, their teachers, and school administrators to gain in-depth information about various factors that contributed to educational outcomes.

The 1995, 1999, and 2003 TIMSS provide information for eighth grade students from 41, 38, and 47 countries, respectively. This study, however, restricts its sample to 10 countries for two reasons. First, countries with almost universal secondary enrollment rates were included in the sample. It is because, if a large proportion of students have left school before grade eight in a country, sample students in TIMSS may not represent the national population of the country. Second, countries with lower than 10 percent of single-sex school enrollment rates (most European and North American countries) and countries with lower than 10 percent of coeducational school enrollment rates (most Middle East countries) were excluded. A comparison of two school types with too few students in one of two school types may not be a reasonable way to examine the effectiveness of single-sex schooling. Another reason for the sample restriction relates to student grade level. The 1995 TIMSS surveyed 20,122 seventh grade students. I excluded the seventh grade students from the sample because the patterns of student learning in a single-sex setting may differ by grade level (Harker 2000). These restrictions left me a total of 103,296 of eighth grade students from 10

countries across the three periods of data collection. Table 1 reports the summary of statistics of the sample including sample sizes for each country.

[Table 1] Summary statistics

Country	Obs	% female students	% in single-sex schools			Math scores			
			All	Boys	Girls	Boys		Girls	
						Single	Mixed	Single	Mixed
Australia	16074	51%	21%	18%	24%	59.8	50.7	56.9	49.5
Belgium	13123	51%	19%	23%	15%	55.0	64.4	69.2	60.5
England	7565	49%	15%	15%	16%	60.4	44.2	57.6	42.2
Hong Kong	10150	50%	23%	21%	24%	74.3	72.8	84.4	70.5
Ireland	3076	50%	48%	40%	56%	56.4	49.4	48.6	46.8
Israel	9850	51%	12%	10%	13%	51.7	47.0	45.3	41.7
Korea	11423	49%	60%	59%	60%	74.5	75.3	73.7	73.2
Malaysia	5314	50%	13%	6%	21%	60.6	49.4	63.1	49.2
New Zealand	11096	50%	33%	32%	33%	49.6	43.3	50.8	43.1
Singapore	15625	49%	21%	20%	22%	87.9	74.1	88.8	75.4

Notes: All statistics are population weighted. Test scores are standardized to mean 50 and standard error 10 across all 63 TIMSS participating countries.

TIMSS test scores used in all of the analyses are standardized within test book across all 63 TIMSS participants to have a mean of 50 and a standard deviation of 10. In Table 1, the country-specific internationally standardized means scores are generally above 50 because, as one would expect, this study is focusing on relatively well performing countries such as many Western European countries and Asian countries. For interpretive ease, this study also uses the percentile scores. These are approximately using the unweighted ranking (0 being the lowest and 100 being the highest) of standardized scores across all the sample countries.

All the models in this study include a basic set of

socioeconomic controls including parental education, student's and parent's immigrant status, whether a student lives with both mother and father, the number of books in the home, information of other types of home possessions, and household size. Unfortunately, some of the socioeconomic controls suffer from substantial non-reporting. As I do not want to lose observations due to missing socioeconomic information, I replace the missing control variable observations with zeros and include a set of missing data indicators. A set of indicators for school selectivity is used in the analysis of this study. If either one of two school types tends to use special school admission standards more often, then such school selectivity may cause a bias in the coefficient for the effectiveness of single-sex schooling. The school selectivity indicators used in this study include whether a school considers students' academic performance or residence in a particular area when admitting students, and whether a school administrator has primary responsibility for hiring teachers, formulating the school budget, or determining teacher salaries.[1] The peer characteristics variables are used in this study as indicators for parental selection toward/against single-sex schools because, if single-sex schools are specialized schools in a country, there may be more sorting based on socioeconomic backgrounds. As for the peer-characteristics indicators, students are assigned the average demographic characteristics across all students in the classroom, excluding the student self. The peer characteristics indicators include the proportion of peers whose farther completed college education, the proportion of peers whose mother completed college education, the proportion of peers who are from immigrant families, and indicators for peer's family income.[2]

1) Woessmann (2003) reports that the degree of school autonomy over the school budget, hiring and rewarding of teachers is positively correlated with students' academic performance of the school.

It is necessary to mention the basic sample design of TIMSS, which is generally referred to as a two-stage stratified cluster sample design. In the first stage, TIMSS selects 150 or more nationally representative schools depending on location, number of pupils, and whether the school is public or private. In the second stage, one classroom in the sampled school is randomly selected and students in that classroom are included in the data set. Due to this sample design, all models are clustered at the school level in order to report conservative inferences.

Ⅲ. Analysis plan

In order to examine the effectiveness of single-sex schooling, this study uses a simple model of student's test score. This model assumes that the test score of student i in school $s(Y_{is})$ is a function of whether school s is a single-sex school (SG_s), the observable characteristics of student i in school $s(X_{is})$, and a mean-zero error term (ϵ_{is}).

$$Y_{is} = \beta_{NP} SG_s + X_{is}\delta_{NP} + \epsilon_{is} \quad (1)$$

where the vector of coefficients δ_{NP} includes the constant coefficient. In equation (1), the coefficient for single-sex school indicator (β_{NP}) measures the effectiveness of single-sex schooling, holding students' socioeconomic background constant.

Some studies suggest that the positive effect of single-sex schooling may be the result of a classroom setting that reduces

2) Peer characteristics in single-sex and coeducational schools are reported in Appendix Table 1.

non-academic distractions and improves confidence/attitudes toward academic subjects (Swan 1998; Sukhnandan et al. 2000). However, it is also possible that the academic gains associated with single-sex schooling may be explained by pre-enrollment differences in student characteristics between two school types due to the selection process (Marsh, 1989, 1991). If so, the coefficient for single-sex school indicator (β_{NP}) may suffer from selection bias if single-sex schools have more strict admission standards or if families from specific socioeconomic spectrum are more likely to send their children to single-sex schools. In order to avoid a bias from selection process, this study measures the effectiveness of single-sex schooling using the following specification.

$$Y_{is} = \beta_P SG_s + X_{is}\delta_P + S_s\gamma_P + \overline{X}_{(-i)s}\pi + \nu_{is} \qquad (2)$$

where the vector of coefficients δ_P includes the constant coefficient, S_s is a vector of school selectivity indicators, $\overline{X}_{(-i)s}$ is a vector of peer characteristics indicators, and ν_{is} is a mean-zero error term. The coefficient for single-sex school indicator (β_P) for equation (2) measures the effectiveness of single-sex schooling with an extensive set of control for selection. Finding substantial differences in the estimated single-sex coefficients across equations (1) and (2) would suggest that pre-enrollment differences in student characteristics between single-sex and coeducational schools are an important component of observed differences in student outcomes across school types. All models are estimated separately by gender and country.

[Table 2] The peer characteristics and single-sex schooling (in standardized scores): Boys

		(1)	(2)	(3)	(4)	(5)
Australia	Coef.	3.17**	1.58	1.35	-1.54*	-1.36
	S.E	(1.16)	(1.07)	(1.15)	(0.84)	(0.87)
	Adj. R^2	0.017	0.149	0.165	0.297	0.309
Belgium	Coef.	-3.20**	-2.23*	-1.90	-1.67**	-1.59**
	S.E	(1.59)	(1.29)	(1.22)	(0.66)	(0.64)
	Adj. R^2	0.024	0.193	0.206	0.465	0.468
England	Coef.	5.46**	4.02**	1.71	1.37	0.05
	S.E	(1.53)	(1.28)	(1.27)	(0.98)	(0.97)
	Adj. R^2	0.045	0.188	0.222	0.312	0.328
Hong Kong	Coef.	0.57	0.45	0.82	-1.01	-0.65
	S.E	(1.39)	(1.10)	(1.12)	(0.75)	(0.78)
	Adj. R^2	0.001	0.127	0.152	0.332	0.344
Ireland	Coef.	2.24	1.53	1.22	1.00	0.40
	S.E	(1.74)	(1.32)	(1.42)	(0.80)	(0.89)
	Adj. R^2	0.014	0.190	0.220	0.451	0.466
Israel	Coef.	1.58	1.79**	1.72**	0.48	0.26
	S.E	(1.07)	(0.80)	(0.86)	(0.83)	(0.85)
	Adj. R^2	0.003	0.231	0.234	0.290	0.296
Korea	Coef.	-0.47	-0.24	-0.18	-0.03	0.07
	S.E	(0.39)	(0.26)	(0.27)	(0.26)	(0.26)
	Adj. R^2	0.001	0.198	0.199	0.204	0.206
Malaysia	Coef.	3.51	1.63	1.63	0.80	0.80
	S.E	(3.49)	(2.66)	(2.66)	(1.67)	(1.67)
	Adj. R^2	0.009	0.139	0.139	0.288	0.288
New Zealand	Coef.	2.07**	0.98	1.34	-0.63	-0.33
	S.E	(1.04)	(0.86)	(0.87)	(0.57)	(0.58)
	Adj. R^2	0.011	0.177	0.191	0.352	0.357
Singapore	Coef.	5.31**	4.17**	4.00**	-1.93**	-1.73**
	S.E	(0.73)	(0.69)	(0.78)	(0.68)	(0.70)
	Adj. R^2	0.070	0.181	0.183	0.470	0.472
Control group						
Family background		-	yes	yes	yes	yes -
School characteristics		-	-	yes	-	yes -
Peer characteristics		-	-	-	yes	yes -

Notes: The coefficients with "**" and "*" are statistically significant at the 10% and 5 % level, respectively. Robust standard errors are in parenthesis. All models are population weighted. All models include control variables listed in the data section. Coefficients shaded in gray are statistically different from coefficients in columns 2 and 7 at 5 percent significance level. All the test scores used in this analysis are standardized score with mean 50 and standard deviation of 10.

[Table 2] The peer characteristics and single-sex schooling (in standardized scores): Girls

		(6)	(7)	(8)	(9)	(10)
Australia	Coef.	2.40**	1.21	1.20	-0.19	-0.03
	S.E	(0.97)	(0.84)	(0.89)	(0.79)	(0.78)
	Adj. R^2	0.014	0.166	0.175	0.282	0.292
Belgium	Coef.	2.81**	2.81**	2.74**	1.86**	1.68**
	S.E	(1.22)	(1.18)	(1.21)	(0.75)	(0.73)
	Adj. R^2	0.014	0.199	0.206	0.468	0.473
England	Coef.	5.06**	3.71**	2.73**	1.02	-0.13
	S.E	(1.40)	(1.00)	(1.08)	(0.79)	(0.75)
	Adj. R^2	0.044	0.234	0.246	0.353	0.361
Hong Kong	Coef.	5.07**	4.74**	4.63**	2.24**	2.22**
	S.E	(0.89)	(0.67)	(0.69)	(0.61)	(0.61)
	Adj. R^2	0.075	0.167	0.181	0.352	0.364
Ireland	Coef.	0.59	-0.03	-0.24	-0.73	-0.33
	S.E	(1.36)	(1.10)	(1.19)	(0.94)	(0.92)
	Adj. R^2	0.001	0.159	0.198	0.376	0.398
Israel	Coef.	1.25	0.30	0.33	-0.44	-0.60
	S.E	(1.06)	(0.68)	(0.66)	(0.66)	(0.71)
	Adj. R^2	0.002	0.203	0.210	0.257	0.264
Korea	Coef.	-0.07	-0.14	-0.16	0.04	0.06
	S.E	(0.44)	(0.27)	(0.27)	(0.29)	(0.30)
	Adj. R^2	0.000	0.219	0.222	0.225	0.227
Malaysia	Coef.	4.58**	1.95	1.95	-1.76*	-1.76*
	S.E	(1.64)	(1.25)	(1.25)	(1.03)	(1.03)
	Adj. R^2	0.049	0.197	0.197	0.356	0.356
New Zealand	Coef.	2.51**	1.44**	1.60**	0.25	0.34
	S.E	(0.76)	(0.62)	(0.61)	(0.48)	(0.48)
	Adj. R^2	0.019	0.193	0.206	0.332	0.338
Singapore	Coef.	5.17**	4.02**	3.93**	-1.36**	-1.39**
	S.E	(0.63)	(0.51)	(0.54)	(0.50)	(0.48)
	Adj. R^2	0.080	0.211	0.214	0.484	0.488
Control group						
Family background		-	yes	yes	yes	yes
School characteristics		-	-	yes	-	yes
Peer characteristics		-	-	-	yes	yes

Notes: The coefficients with "**" and "*" are statistically significant at the 10% and 5 % level, respectively. Robust standard errorsare in parenthesis. All models are population weighted. All models include control variables listed in the data section. Coefficients shaded in gray are statistically different from coefficients in columns 2 and 7 at 5 percent significance level. All the test scores used in this analysis are standardized score with mean 50 and standard deviation of 10.

[Table 3] The peer characteristics and single-sex schooling (in percentile scores): Boys

		(1)	(2)	(3)	(4)	(5)
Australia	Coef.	9.15**	4.34	3.48	-5.14**	-4.69*
	S.E	(3.35)	(3.04)	(3.23)	(2.45)	(2.52)
	Adj. R^2	0.016	0.145	0.162	0.294	0.306
Belgium	Coef.	-9.37*	-6.58*	-5.58	-4.92**	-4.67**
	S.E	(4.81)	(3.96)	(3.73)	(2.04)	(1.98)
	Adj. R^2	0.022	0.193	0.207	0.469	0.473
England	Coef.	16.24**	11.83**	4.69	3.66	-0.34
	S.E	(4.58)	(3.82)	(3.72)	(2.93)	(2.90)
	Adj. R^2	0.043	0.186	0.221	0.313	0.329
Hong Kong	Coef.	1.45	1.02	2.07	-2.53	-1.43
	S.E	(3.91)	(3.20)	(3.21)	(2.22)	(2.30)
	Adj. R^2	0.000	0.117	0.146	0.318	0.332
Ireland	Coef.	7.01	4.94	4.03	3.38	1.61
	S.E	(5.22)	(4.00)	(4.31)	(2.50)	(2.77)
	Adj. R^2	0.014	0.187	0.218	0.445	0.460
Israel	Coef.	4.70*	5.58**	5.35**	1.47	0.75
	S.E	(3.19)	(2.40)	(2.57)	(2.50)	(2.57)
	Adj. R^2	0.003	0.227	0.230	0.285	0.291
Korea	Coef.	-0.72	-0.42	-0.19	0.09	0.43
	S.E	(1.01)	(0.71)	(0.72)	(0.72)	(0.69)
	Adj. R^2	0.000	0.184	0.186	0.190	0.192
Malaysia	Coef.	11.15	5.54	5.54	3.15	3.15
	S.E	(10.6)	(8.11)	(8.11)	(5.02)	(5.02)
	Adj. R^2	0.009	0.138	0.138	0.288	0.288
New Zealand	Coef.	6.31**	2.94	4.07	-1.94	-1.00
	S.E	(3.20)	(2.65)	(2.66)	(1.75)	(1.76)
	Adj. R^2	0.011	0.175	0.189	0.351	0.357
Singapore	Coef.	13.80**	10.27**	9.53**	-5.89**	-5.47**
	S.E	(1.77)	(1.82)	(2.02)	(1.96)	(2.00)
	Adj. R^2	0.061	0.155	0.157	0.440	0.441
Control group						
Family background		-	yes	yes	yes	yes
School characteristics		-	-	yes	-	yes
Peer characteristics		-	-	-	yes	yes

Notes: The coefficients with "**" and "*" are statistically significant at the 10% and 5 % level, respectively. Robust standard errors are in parenthesis. All models are population weighted. All models include control variables listed in the data section. Coefficients shaded in gray are statistically different from coefficients in columns 2 and 7 at 5 percent significance level. All the test scores used in this analysis are percentile scores across all 10 sample countries.

[Table 3] The peer characteristics and single-sex schooling (in percentile scores): Girls

		(6)	(7)	(8)	(9)	(10)
Australia	Coef.	7.35**	3.66	3.66	-0.57	-0.06
	S.E	(3.05)	(2.62)	(2.75)	(2.41)	(2.38)
	Adj. R^2	0.014	0.167	0.176	0.284	0.294
Belgium	Coef.	8.75**	8.62**	8.40**	5.70**	5.16**
	S.E	(3.77)	(3.69)	(3.76)	(2.31)	(2.27)
	Adj. R^2	0.015	0.199	0.207	0.473	0.479
England	Coef.	15.42**	11.38**	8.26**	3.21	-0.38
	S.E	(4.25)	(3.06)	(3.28)	(2.42)	(2.28)
	Adj. R^2	0.044	0.230	0.243	0.351	0.360
Hong Kong	Coef.	13.94**	13.00**	12.63**	6.26**	6.17**
	S.E	(2.38)	(1.90)	(1.97)	(1.76)	(1.76)
	Adj. R^2	0.069	0.147	0.164	0.335	0.349
Ireland	Coef.	1.79	-0.20	-0.87	-2.29	-1.08
	S.E	(4.19)	(3.41)	(3.68)	(2.92)	(2.87)
	Adj. R^2	0.001	0.158	0.198	0.381	0.404
Israel	Coef.	3.56	0.89	0.95	-1.34	-1.74
	S.E	(3.18)	(2.07)	(2.01)	(2.00)	(2.15)
	Adj. R^2	0.002	0.199	0.207	0.254	0.261
Korea	Coef.	0.49	-0.11	-0.14	0.26	0.33
	S.E	(1.16)	(0.76)	(0.76)	(0.82)	(0.84)
	Adj. R^2	0.000	0.209	0.213	0.214	0.217
Malaysia	Coef.	13.93**	5.95	5.95	-5.22*	-5.22*
	S.E	(4.90)	(3.74)	(3.74)	(3.16)	(3.16)
	Adj. R^2	0.048	0.194	0.194	0.352	0.352
New Zealand	Coef.	7.73**	4.40**	4.91**	0.75	1.02
	S.E	(2.33)	(1.92)	(1.90)	(1.49)	(1.48)
	Adj. R^2	0.019	0.189	0.203	0.330	0.336
Singapore	Coef.	13.49**	10.24**	9.78**	-3.83**	-4.02**
	S.E	(1.52)	(1.33)	(1.40)	(1.37)	(1.34)
	Adj. R^2	0.072	0.174	0.177	0.452	0.456
Control group						
Family background		-	yes	yes	yes	yes
School characteristics		-	-	yes	-	yes
Peer characteristics		-	-	-	yes	yes

Notes: The coefficients with "**" and "*" are statistically significant at the 10% and 5 % level, respectively. Robust standard errors are in parenthesis. All models are population weighted. All models include control variables listed in the data section. Coefficients shaded in gray are statistically different from coefficients in columns 2 and 7 at 5 percent significance level. All the test scores used in this analysis are percentile scores across all 10 sample countries.

Ⅳ. Results

4.1 Base model

Table 2 compares the estimates using equations (1) and (2) for eighth grade math achievement in 10 countries using standardized scores. For interpretive ease, Table 3 reports the same results using the percentile scores. Given the easier interpretation of the percentile scores, the text focuses on these results.

The mean difference in math test scores between single-sex and coeducational schools for boys and girls, respectively, are reported in columns 1 and 6. Columns 2 and 7 show the impact of single-sex schooling on math test scores for boys and girls, respectively, with basic socioeconomic controls using equation (1). The results in column 2 show that boys in Belgian single-sex schools score significantly lower than their counterparts in coeducational schools, while boys in single-sex schools score significantly higher than boys in coeducational schools in England, Israel, and Singapore. In other six countries, single-sex schooling has no significant impact on boys' test scores. Column 7 shows that, in Belgium, England, Hong Kong, New Zealand, and Singapore, girls in single-sex schools score significantly higher than girls in coeducational schools. However, in other five countries, single-sex schooling has no significant impact on girls' test scores.

A cross-country comparison of the estimates in columns 2 and 7 illustrates one important fact regarding the effectiveness of single-sex schooling; single-sex education has a stronger impact in countries that offer only a small proportion of single-sex schooling. For example, in Belgium, many all-boys' secondary schools are religious schools that emphasize religious education than academic success and only 10 percent of male students attend single-sex schools. The estimate in column 2 indicates that Belgian boys in

single-sex schools score significantly lower than their counterparts in coeducational schools by 6.6 percentiles. In countries where single-sex schools are more likely to be elite schools, academic achievement levels of single-sex school students tend to be much higher than those of coeducational school students. For example, in countries with low male single-sex school enrollment rates such as England (15 percent), Israel (10 percent), and Singapore (20 percent), boys in single-sex schools score significantly higher than boys in coeducational schools by 11.8 percentiles, 5.6 percentiles, and 10.3 percentiles, respectively. In countries with low female single-sex school enrollment rates such as Belgium (15 percent), England (16 percent), Hong Kong (24 percent), New Zealand (33 percent), and Singapore (23 percent), girls in single-sex schools score significantly higher than their counterparts in coeducational schools by 8.6 percentiles, 11.4 percentiles, 13.0 percentiles, 4.4 percentiles, and 10.2 percentiles, respectively. On the other hand, in countries with higher single-sex school enrollment rates such as Ireland (48 percent) and Korea (60 percent), there is little difference in math test scores between students in single-sex and coeducational schools. This finding suggests that it is important to include control variables for the potential pre-enrollment differences in student characteristics between specialized schools and common schools, or between single-sex schools and coeducational schools in some countries, in order to examine the true impact of single-sex education.

4.2 Models with peer group controls

A comparative analysis of columns 2-5 and columns 7-10 illustrates the importance of including controls for school selectivity and parental selection. Columns 3 and 8 show the estimated impact of single-sex schooling with school selectivity

control. Including school selectivity indicators improves the R-squared of the model slightly, however, it does not change the magnitudes of coefficients for single-sex schooling except for the estimate for boys in England. In England, when school selectivity controls are included in the model, the magnitude of the coefficient for single-sex schooling on boys' test scores decreases from 11.8 percentiles to 4.7 percentiles and the difference is statistically significant at 5 percent level.

Columns 4-5 and columns 9-10 show that, in many countries, the single-sex school coefficients change substantially when peer group controls are added to the list of regressors. This suggests that in the absence of peer controls, the single-sex measure is partial proxy for the missing peer group characteristics. More specifically, comparing columns 2 and 5 shows that, if peer group characteristics are held constant, the coefficients for the impact of single-sex schooling on boys' test scores significantly decrease in magnitude. Moreover, these differences are statistically significant at the 5 percent level in six countries (Australia, England, Israel, Korea, New Zealand, and Singapore) out of 10 countries. A comparison of female estimates in columns 7 and 10 also shows a significant decrease in magnitude. These differences are statistically significant at the 5 percent level in six countries (Australia, England, Hong Kong, Malaysia, New Zealand, and Singapore) out of 10 countries. As such, peer characteristics are important factors in the analysis of the effectiveness of single-sex schooling because they help to filter out the achievement gaps associated with pre-enrollment differences in student characteristics between single-sex and coeducational schools. This supports the hypothesis of the paper; school selectivity and parental selection explain at least some of the observed academic achievement gaps between single-sex and coeducational schools. For example, in England,

single-sex schools are more likely to be highly selective private schools and tend to attract high achieving students from advantaged family backgrounds. The estimates without peer group controls show a large achievement gap favoring single-sex schools. Significantly differing measures for the impact of single-sex schooling, however, suggest that the observed academic advantages for students in single-sex schools is more likely to be associated with pre-enrollment differences in student characteristics than with a special classroom setting that reduces non-academic distractions. On the other hand, differences both in peer group characteristics and in achievement are less expected and not found in Ireland, where single-sex schools are not necessarily connected to future educational opportunities. In Ireland, a large number of single-sex schools are still operating because these older traditions are supported by the majority of the population. Different from single-sex schools in England, single-sex schools in Ireland follow the same regulations in terms of curriculum, textbook, and student admission policies. The estimates in Table 3 show that peer group controls do not factor into understanding the effectiveness of single-sex schooling in Ireland. A comparative study suggests that, in Ireland, single-sex schooling may have little influence on student academic achievement.

The estimates with peer controls suggest that single-sex schooling does not always have a positive impact on student achievement levels. The estimates in column 5 indicate that single-sex schooling may have a negative impact on boys' academic achievement levels in three countries (Australia, Belgium, and Singapore) and may have no impact at all in seven countries (England, Hong Kong, Ireland, Israel, Korea, Malaysia, and New Zealand). The estimates in column 10 show that single-sex schooling may have no impact on girls' math achievement levels

in six countries (Australia, England, Ireland, Israel, Korea, and New Zealand), have a negative impact in two countries (Malaysia and Singapore), and have a positive but much smaller impact compared to the estimates without peer controls in two countries (Belgium and Hong Kong).

Ⅴ. Conclusion and Implication

The results of this paper confirm that peer group characteristics are more important in explaining the effectiveness of single-sex education when the proportion of students in single-sex schools is smaller in the education system. In countries with higher single-sex school enrollment such as Korea, little differences are expected in peer characteristics among students who enrolled in the two different types of schools because single-sex schools are not necessarily attracting higher ability students or students from advantaged families. The results in this paper confirm that including peer controls in the analysis has little influence on the estimation results. In countries that offer only a small proportion of single-sex education such as Singapore, peer characteristics in single-sex schools tend to differ considerably from that in coeducational schools because elite single-sex schools are more likely to have students who are high achieving and highly motivated. A comparison of two different measures shows a considerable decrease in magnitude, which emphasizes the importance of peer control in the analysis of effectiveness of single-sex schools.

The results of the international comparative study suggest that peer group control variables may be capturing achievement gaps associated with the potential pre-enrollment differences in student

characteristics between single-sex and coeducational schools. In other words, using peer group control variables as an indicator for pre-enrollment differences in student characteristics across the two types of schools, the models in this paper attempt to circumvent the potential selectivity problems associated with single-sex education. The hypotheses about the peer characteristics and the effectiveness of single-sex education are largely confirmed, although the results are not consistent. The strongest argument is made by comparing Australia, England, New Zealand, and Singapore - countries that are well-known for their single-sex schools with rigorous entrance standards, demanding curriculum, and high achievement standards for students. In these four countries, a comparative study of two different measures reveals that there is no academic benefit from single-sex schooling if pre-existing differences in student characteristics are controlled by peer characteristic variables.

The findings of this paper suggest that the significant impact of single-sex schooling on academic achievement may have been driven by the relative rarity of single-sex classroom settings.[3] When they are outside of the mainstream of an education system, single-sex schools often differ in major elements of an educational environment such as curriculum, pace of instruction, teacher qualifications, and achievement standards for students. Therefore, they tend to attract characteristically different students compared to mainstream schools. This pre-existing difference in student

3) This paper examines the effect of single-sex schooling on academic achievement in middle school. It is possible that single-sex schooling may have more significant impact on high school students than it does on middle school students. While the TIMSS provide test scores and other information of highschool seniors, the sample of high school seniors in the TIMSS is not a nationally representative sample in most countries. Further study on the effect of single-sex schooling on high school students using a representative sample would add more information on the literature.

characteristics is often associated with distinct academic achievement of students. On the other hand, when single-sex schooling is simply a large part of mainstream education systems, this single-sex classroom setting seems to have little influence on student educational outcomes.

This international comparison has important implications for the single-sex schooling literature. While most of previous studies disagree as to whether or not single-sex education benefits students, this study illustrates that the impact varies across education systems depending on the specific setting of the education system. One of the most noticeable findings is that single-sex schooling has a significant impact on student achievement when only a small proportion of students attend single-sex schools in the education system. Moreover, the impact of single-sex schooling on achievement differs substantially among those countries with relatively low single-sex school enrollment rate. For example, British students attending elite single-sex schools tend to score significantly higher on their standardized tests on major subjects such as math and science. On the other hand, Belgian male students attending religious single-sex schools tend to score significantly lower on their tests. This association between the effectiveness of a special education setting and the overall characteristics of national education system may require more attention.

This paper has important implications on future educational policies promoting single-sex education. First, separating boys and girls in different classrooms does not always guarantee a positive effect on students' academic achievement. Single-sex schooling may positively influence students' test scores by eliminating non-educational distraction within the classroom, or by providing boys and girls their own learning spaces, or by employing gender

specific teaching techniques. However, this study shows that most of the effects are related to the selection process, which was controlled by peer characteristics in this study. Second, allowing diversity in learning environment may lead to more and greater variance in standardized test scores across school types. For example, specialized schools tend to offer different educational opportunities to their students: religious education, elite education, social connection, or other special education. The differences in learning environments across school types lead peer group characteristics to vary much more across school types and this variance seems to be associated with the observed differences in educational outcomes. Also, small sector schools can provide a more target oriented learning environment in terms of curriculum, student-student interactions, student-teacher interactions, and pace of instruction. As the specialization of schools increase, it may intensify concern over school choice among students and their parents. Consequently, students would demand different qualities from different schools and cross-school difference would also increase.

Single-sex education may benefit at least some students in various educational outcomes. Single-sex schools tend to provide a more academically oriented environment, which leads to greater interest in academics, higher levels of effort on schoolwork, and higher test scores among single-sex school students (Trickett et al 1982). Single-sex schooling helps students to have more positive attitudes toward courses traditionally associated with the opposite sex (Gwizdala and Steinback 1990). Whether or not publicly funded education should support the special needs of single-sex schooling is a murky area of social decision based on cultural tolerance to seemingly anachronistic school organization and social perception over the gender equity in educational opportunities and

outcomes. Issues that are more practical would be to objectively characterize a subset of students who need this type of special educational environment; and to find efficient and fair ways to provide an alternative educational opportunity to those who have special needs.

Received: September 17, 2009. Revised: December 5, 2009. Accepted: December 9, 2009.

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[Appendix Table 1] Difference between SG and CE students

Country				Australia	Belgium	England	Hong Kong	Ireland	Israel	Korea	Malaysia	New Zealand	Singapore
School Admission Policy		Academic Skills	SG	55%	11%	22%	5%	94%	10%	55%	-	44%	-
			CE	50%	12%	48%	5%	96%	38%	43%	-	51%	-
		Regions	SG	33%	12%	25%	12%	24%	17%	26%	-	31%	-
			CE	14%	28%	3%	8%	21%	6%	17%	-	17%	-
Peer Characteristics	Mother's Education	Less than high school	SG	21%	16%	2%	34%	29%	8%	24%	34%	11%	26%
			CE	25%	17%	1%	47%	34%	14%	21%	46%	13%	51%
		College or more	SG	21%	10%	5%	8%	10%	24%	11%	8%	18%	13%
			CE	13%	9%	2%	3%	9%	24%	16%	3%	12%	3%
	Father's education	Less thanhigh school	SG	16%	15%	1%	32%	32%	8%	16%	26%	12%	19%
			CE	22%	14%	1%	43%	37%	15%	14%	37%	15%	40%
		College or more	SG	28%	15%	6%	14%	14%	22%	24%	15%	20%	22%
			CE	15%	13%	2%	5%	9%	23%	30%	7%	13%	5%
	Immigrant status	Student's mother	SG	46%	15%	31%	42%	11%	40%	3%	8%	32%	25%
			CE	35%	15%	21%	53%	12%	40%	3%	7%	30%	25%
		Student's father	SG	48%	16%	33%	41%	10%	50%	3%	7%	34%	26%
			CE	37%	17%	22%	52%	12%	44%	3%	7%	33%	24%

동료집단의 특성과 비남녀공학학교의 효과: 학업성취도에 대한 영향을 중심으로

조 인 숙*

논문초록

일반 남녀공학에 비해 보다 효율적인 교육환경을 제공한다는 의견을 바탕으로, 최근 비남녀공학에 다니는 학생들의 학업성취도에 미치는 영향에 대한 관심이 커져왔다. 그러나 남녀공학과 비남녀공학에 진학하는 학생들이 여러 가지 면에서 서로 다른 특성을 보이기도 하는데, 따라서 관찰되는 비남녀공학의 학업성취도에 대한 긍정적인 효과는, 상당수의 나라에서는 선택편의에 의한 영향과 잘 구별되지 않기도 한다. 이 논문은 남녀공학 및 비남녀공학 학생들의 학업성취도의 차이에 대한 국제비교를 해본다. 특히 이 논문은 비남녀공학학교에 진학하는 것이 언제나 학업성취도에 긍정적인 영향을 주는 것이 아니며, 비남녀공학의 긍정적인 효과의 상당부분이 선택편의에 의해 설명된다는 것을 보여준다.

주제분류 : B030400
핵심 주제어 : 동료집단, 학업성취도, 학교선택

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