Discussion Paper Series
No. 2106
November 2021

How Long Does It Last?

The Relative Age Effect in Korean Elementary Education

By Dirk Bethmann and Jae Il Cho

The Institute of Economic Research – Korea University
Anam-dong, Sungbuk-ku, Seoul, 136-701, South Korea, Tel: (82-2) 3290-1632, Fax: (82-2) 928-4948

How Long Does It Last?

The Relative Age Effect in Korean Elementary Education

By Dirk Bethmann[1] and Jae Il Cho[2]

Abstract

An elementary school student's relative age is defined as the child's age relative to the age of its classmates. To what extent relative age gaps influence academic outcomes is an ongoing debate in educational economics and related fields. Our study analyzes the existence, magnitude, and duration of relative age effects in South Korea for various school subjects. Our results show that relative age effects are stronger for science related subjects and that they disappear after students graduate from elementary school and start their secondary school education.

JEL: I20, I21, J13

Keywords: relative age effect; seasonal birth; academic achievement

[1] Korea University; Department of Economics, 145 Anam-ro, South Korea; dirk@korea.ac.kr

[2] Corresponding author: Vanderbilt University; Department of Economics; 010-back Calhoun Hall, Nashville, TN, 37240, United States; Tel. +01-615-423-1395, jae.il.cho@vanderbilt.edu

I. Introduction

An extensive literature shows that relative age gaps among young elementary school students significantly affect academic as well as social outcomes (see, for example, Puhani & Weber, 2006; Kawaguchi, 2011; Sprietsma, 2008; Robertson, 2011). In addition, there are studies with a wider focus that aim at examining the effects on adulthood outcomes such as employment, educational attainment, and hourly wages (Dobkin & Ferreira, 2010; Black, Devereux & Salvanes, 2011; Grenet, 2011; Fredriksson & Ö Ckert, 2013; Nam, 2014). These studies have produced mixed results. Dobkin & Ferreira (2010) and Nam (2014) find very weak or no relative age effects on adulthood outcome variables. In contrast, Black, Devereux, & Salvanes (2011), Grenet (2011), and Fredriksson & Ö Ckert (2013) find that relative age effects last until adulthood. Black, Devereux, & Salvanes (2011) state that relative age affects earnings up to 11.6% for females and 9.9% for males at the early stage of careers but the effect disappears by the age of 30. Grenet (2011) shows relatively older tend to be more academically qualified and more likely to be employed than the relatively young.

In Korea, relative age effects and academic outcomes are long-standing concerns of parents with children born in later months of academic cohorts (Hong, Kim, & Byun, 2010; Lee, 2011; Yun, 2017). Our primary goal is therefore to investigate these effects on elementary school students using data from the Korean Children and Youth Panel Survey. Our analysis goes beyond checking for the mere existence of relative age effects but instead also focuses on both the magnitude and longitude of these effects as this is crucial information for policy makers as well as current and future parents. Another contribution of our study is that we are analyzing the relative age effects for different subjects (i.e. Mathematics, Social Science, Natural Science, Korean, and English). Such a subject-wise quantification of relative age effects is so far under researched in the existing literature. Notable exceptions are studies by Kawaguchi (2011), Robertson (2011), and Nam (2014).

Our results show that relative age effects exist for young elementary school students in most academic subjects except English. The magnitude is stronger for the hard sciences (i.e. mathematics and natural science) than for language subjects (Korean and English). Moreover, the relative age effect lasts until the 4th grade before it becomes insignificant. In social science we find relative age effects that last until the end of elementary school.

II. Data

Our study uses the Korean Children and Youth Panel Survey (KCYPS). The panel structure of the data set allows us to trace the same student cohort from their first grade (first wave of the KCYPS in 2010) to their seventh grade (seventh wave of the KCYPS in 2016). A total of 2,342 students is surveyed for the first wave. Student performance in mathematics, social science, natural science, Korean, and English is measured by categorical outcome variables ranging from very good (5) to very poor (1). Because English education starts from grade three, the first learning outcomes can be observed in grade three. For all other subjects observations start from grade two. Table 1 summarizes the learning results in mathematics (Math), social science (SoSci)[3], natural science (NaSci), Korean and English after pooling from the second to the sixth grade.

[3] We used the "Ethics" course outcome for 2nd grade students as they officially learn "Social Science" course from the 3rd grade.

Table 1: Descriptive Statistics for Outcome Variables

Variable	**Mean (SD)**	**5**	**4**	**3**	**2**	**1**	**Obs**
Math	3.7929 (0.9760)	2,912	3,835	3,021	795	175	10738
SoSci	3.7287 (0.9423)	2,471	3,973	3,342	808	142	10736
NaSci	3.8781 (0.8728)	2,837	4,357	3,003	466	70	10733
Korean	3.9428 (0.8133)	2,828	4,839	2,763	245	63	10738
English	3.9059 (1.0495)	3,068	2,603	1,942	683	186	8482

Notes: Descriptive statistics after pooling the data from 2nd grade to 6th grade students. 5 denotes very good; 4, good; 3, average; 2, poor; 1, very poor. Standard deviations are in parenthesis.

The KCYPS dataset has detailed family background information such as mother's education, father's education, and family income in Korean Won (KRW). The descriptive statistics for family background are shown in Table 2.

Table 2: Descriptive Statistics for Family Backgrounds

Variable	**Obs**	**Mean (SD)**	**Median**	**Definition**
MoEdc	10,224	2.8880 (0.9365)	3	Mother's Education
FaEdc	10,144	3.0916 (1.0252)	3	Father's Education
Income	10,336	4821.39 (2542.28)	45000	Household Income in 10,000 KRW

Note: The table shows the descriptive statistics after pooling the data from 2nd grade to 6th grade students. Parents' education is categorized as follows: 1 = Middle School or Less; 2 = High School; 3 = Community College; 4 = University; 5 = Graduate School. Standard deviations are in parenthesis.

The dataset also offers information on personal characteristics such as tutoring time, assignment time, health and sex. Table 3 summarizes the descriptive statistics for these personal characteristics. Note that private tutoring time exceeds the time for take-home assignments by a factor of three to four. This is a common finding in Korea. Elementary school students study on average 122 minutes daily after attending school: the largest portion comes from private tutoring (Statistics Korea, 2014).

Table 3: Descriptive Statistics for Personal Characteristics

Variable	**Obs**	**Mean (SD)**	**Median**	**Definition**
TutorT	10,661	123.0536 (76.57417)	120	Average Tutoring Time per Day (in minutes)
AssignT	10,648	40.49014 (28.8207)	30	Average Assignment Time per Day (in minutes)
Health	10,700	1.670748 (0.5416604)	2	Personal Health
Sex	10,738	1.484448 (0.4997813)	1	Sex

Note: The table shows the descriptive statistics after pooling the data from 2nd grade to 6th grade students. Health is categorized as follows: 1 = very healthy; 2 = healthy; 3 = somewhat not healthy; 4 = not healthy. Sex is categorized as follows: 1 = male; 2 = female.

Our main explanatory variable relative age is calculated based on birth year and month. Table 4 shows the distribution of birth years and months in the data set.

Table 4: Birth Year and Month

Birth Year	**Birth Month**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2002		4			5				19	15	9	22
2003	799	916	920	1,019	785	783	808	862	936	885	876	791
2004	171	83	10	5			5			5	5	

Note: The table displays students' birth year and month after pooling the data from 2nd grade to 6th grade students. Our main explanatory variable relative age is calculated based on the birth year and month. 2003 December born students are assigned 1 for the relative age; 2003 March born, 10 for the main regression.

Students born in 2002 and 2004 are excluded in the main regressions because those are students who postponed or advanced school entry for personal or health issues. Moreover, due to a policy change[4], students born in January and February in 2003 are excluded in our main regressions as they had an option to choose which academic cohort to join. If they chose

[4] Until 2007, Korean students born between March 1st and the end of February the following year were grouped into the same academic year. In 2007, the Korean government modified the birth months of academic cohorts so that they now coincide with calendar years. During the transitional period, parents of students born in January and February of 2003 could apply for an early school entry or choose to join the regular cohort. A similar choice has been and still is in place for students with special needs. Parents of students with physical and mental disabilities who wish to study at a regular school can register their children with a one year delay.

to join the regular cohort, they might be better prepared for elementary school than their peers because they had in fact one more year, which may cause endogeneity issues when estimating the relative age effects. In our empirical analysis we measure relative age as follows: 2003 December borns are assigned 1 for the relative age; and 2003 March borns are assigned 10. This follows the procedure in Nam (2014) where students' age by month is the main control variable. Because our study uses only 2003 born students, our relative age variable will capture the same effect.

III. Empirical Strategy

Most empirical studies that test relative age or seasonal effects use ordinary least squares, instrumental variable, or regression discontinuity methods. For instance, Lawlor *et al* (2006), Dhuey & Lipscomb (2008), Kawaguchi (2011), Sprietsma (2008), and Robertson (2011) use ordinary least squares estimations to measure the relative age effect; Datar (2006), Puhani & Weber (2006), Smith (2010), and Nam (2014) use instrumental variable regressions. Studies that have used the regression discontinuity design include Dobkin & Ferreira (2010), Fredriksson & Ö Ckert (2013), Crawford, Dearden, & Greaves (2014). Instrumental variable and regression discontinuity methods are typically used with cross sectional data where the observed age in months and the relative age from zero to eleven are not in a linear relationship. However, the data that this study uses is panel data from first graders. In other words, the observed age in months and the relative age are linear dependent and hence give the same variation. Thus, we mainly use ordinary least squares.

In a first step, we pool the information from the second to the sixth grade and check for the existence of relative age effects in a pooled OLS regression. The performance measures Math, NaSci, SoSci, Korean, and English are our outcome variables. Control variables include TutorT, Health, AssignT, MoEdc, FaEdc, Income, Sex, and school districts.

It is well-known that family background characteristics such as parental education levels and household income strongly influence the academic performance of students (Davis-Kean, 2005; Duncan, Morris, & Rodrigues, 2011; Dahl & Lochner, 2012). Thus, we control for mother's and father's education as well as household income in our regressions. Moreover, private tutoring is very wide-spread among Korean students (see also Table 3). According to Statistics Korea (2018), more than 80 percent of elementary school students receive additional private tutoring. It is therefore essential to control for private tutoring. Health is also included as a control variable since a student's physical condition can influence her or his academic performance. The regression equation for the pooled data is

$$\text{Outcome} = \beta_0 + \beta_1 Grade + \beta_2 RelatAge + \beta_3 X + \beta_4 Z + \varepsilon \qquad (1)$$

where ε is assumed to have the usual ideal properties. Outcome represents the academic performance of Math, SoSci, NaSci, Korean, and English (i.e. we run a total of five pooled OLS regressions). RelatAge is the variable of interest and varies between one and ten. A student born in December 2003 is assigned '1' and a March 2003 born is assigned '10'. X represents family background variables such as FaEdc, MoEdc, Income, and also the school district. Z is the vector for personal characteristics such as TutorT, AssignT, Health, and Sex.

In a next step, we run separate OLS regressions using the same model without pooling the data by grades such that we obtain grade-specific results. This way we hope to learn more about the duration of relative age effects:

$$\text{Outcome} = \beta_0 + \beta_1 RelatAge + \beta_2 X + \beta_3 Z + \varepsilon \qquad (2)$$

In total 24 OLS regressions are performed (second to sixth grade times five subjects minus one because English education starts with the third grade). In our robustness checks, we also

impose the Tobit regression model since the dependent variable is bounded from 1 to 5 categorically. Further robustness checks are performed by using outcome variables from the seventh wave of the KCYPS, i.e. when the student cohort became seventh-graders and entered middle school.

IV. Results

Table 5 presents the results of our pooled OLS regression analysis. Each column refers to a separate regression for the respective outcome variable.

Table 5: Relative Age Effects by Subjects (Pooled OLS Regressions)

Variables	Math	SoSci	NaSci	Korean	English
Grade					
3	-0.111617***	-0.440309***	-0.090297***	0.005127	
	(0.032606)	(0.031639)	(0.029603)	(0.027748)	
4	-0.074983**	-0.382776***	-0.233881***	0.065594**	-0.066091*
	(0.033072)	(0.032097)	(0.030027)	(0.028144)	(0.035612)
5	-0.183008***	-0.411144***	-0.267028***	0.069690**	-0.153224***
	(0.033073)	(0.032098)	(0.030017)	(0.028145)	(0.035600)
6	-0.143979***	-0.349246***	-0.338086***	0.110344***	-0.145755***
	(0.033243)	(0.032257)	(0.030175)	(0.028289)	(0.035755)
RelatAge	0.017579***	0.016159***	0.009813***	0.011547***	0.004700
	(0.003731)	(0.003621)	(0.003388)	(0.003175)	(0.004476)
TutorT	0.001517***	0.000545***	0.000502***	0.000406***	0.001616***
	(0.000144)	(0.000140)	(0.000131)	(0.000123)	(0.000172)
Health	-0.171495***	-0.170544***	-0.175152***	-0.161862***	-0.222635***
	(0.020065)	(0.019471)	(0.018214)	(0.017075)	(0.023674)
AssignT	-0.000251	0.000339	0.000328	0.000248	0.000076
	(0.000370)	(0.000360)	(0.000336)	(0.000315)	(0.000429)
MoEdc					
2	0.655852***	0.321274***	0.189888*	0.280807***	0.430230***
	(0.124208)	(0.120524)	(0.112732)	(0.105699)	(0.143237)
3	0.703130***	0.407830***	0.237761**	0.376935***	0.618207***
	(0.126219)	(0.122475)	(0.114558)	(0.107410)	(0.145760)
4	0.740396***	0.492533***	0.294690**	0.379535***	0.588875***
	(0.127203)	(0.123431)	(0.115455)	(0.108248)	(0.146960)
5	0.803263***	0.567143***	0.417882***	0.480325***	0.709103***
	(0.142136)	(0.137920)	(0.129007)	(0.120955)	(0.165457)
FaEdc					
2	0.114137	-0.106981	0.071933	0.033392	0.213197
	(0.116212)	(0.112765)	(0.105474)	(0.098894)	(0.139139)
3	0.159487	-0.060079	0.114762	0.092352	0.291881**
	(0.118777)	(0.115254)	(0.107802)	(0.101077)	(0.142252)
4	0.214605*	0.013078	0.159578	0.110465	0.412849***
	(0.119119)	(0.115585)	(0.108118)	(0.101368)	(0.142615)
5	0.282001**	0.101160	0.256382**	0.202948*	0.464115***
	(0.126458)	(0.122709)	(0.114777)	(0.107614)	(0.151585)
Income	0.000013***	0.000009*	0.000002	0.000005	0.000027***
	(0.000005)	(0.000005)	(0.000004)	(0.000004)	(0.000006)
Sex	-0.237383***	-0.005900	-0.054090***	0.203042***	0.132953***
	(0.021411)	(0.020779)	(0.019438)	(0.018220)	(0.025686)
Obs	7812	7,810	7,807	7,812	6,139
R^2	0.1081	0.1028	0.0805	0.0863	0.1380

Note: A total of 127 School Districts is controlled in the regressions but not displayed in the table.
Standard errors are in parenthesis
* denotes p<0.10, ** denotes p<0.05, *** denotes p<0.01

In general, students' performance but also their confidence in academic subjects decreases as their grades proceed since students have to learn more difficult concepts.[5] Thus, the coefficients for grades are negative for most of subjects. Korean language education is an exception: students' performance and confidence in Korean get better as their grade proceeds since the speed of linguistic development is fast for elementary school students. Evidence suggests that language acquisition is most active until the age of 5, but keeps progressing rapidly until puberty around age of 12 or 13 (Ohasi, 2006; Fromkin, Rodman, & Hyams, 2014). In other words, the speed of linguistic development of children is likely to outperform the rate of increase in academic requirements in Korean language classes.

Reassuringly, our results also confirm the notion that the individual family back ground is an important determinant of academic performance. Private tutoring time, parents' educational level, and household income positively affect the performance of students. As mentioned earlier, private tutoring of elementary school students is very common in Korea. More than 80% of Korean elementary students are getting extra training after school through private tutoring (Statistics Korea, 2018). As can be seen, this private tutoring time affects the academic performance with high statistical significance for all subjects. Time spent on school assignments, in contrast, is not statistically significant. An explanation for this finding might be that assignment time and private tutoring time are indeed close substitutes. Simply speaking, if students spend much time in private tutoring, they would have less time for school assignments. In fact private tutors assist with school assignments and exam preparation. Along with private tutoring time, the parents' education level also affects the academic performance of students. Compared to the father's education level, the mother's

[5] In mathematics, for example, second grade students mainly learn numerical addition and subtraction of four digit numbers, characteristics of two-dimensional shapes, definition of measurements, and chart organization while sixth grade students learn common factors, calculation of rational numbers, volumes of three-dimensional shapes, basic statistics, and probability (The Ministry of Education, 2015).

education level tends to affect the academic performance more: mother's education level is statistically significant for all subjects with bigger magnitude while father's education level is statistically significant only for certain subjects. Household income also affects the academic performance of students in mathematics, social science, and English with high statistical significance.

Individual characteristics such as personal health and sex are also important determinants for academic performance. Students' health, for instance, affects academic performance. For all subjects, students with poor health tend to underperform with high statistical significance. Interestingly, male students perform on the average better in science such as mathematics and natural science. Female students, in contrast, perform better in languages such as Korean and English. These results are in line with several previous studies on gender gaps by academic subjects (Davies, 2004; Baram-Tsabari & Yarden, 2010; Kim, Al Otaiba, Wanzek, & Gatlin, 2015; Wang & Degol, 2016).

Most importantly, the relative age effect exists among elementary school students with high statistical significance in most of the subjects such as mathematics, social science, natural science, and Korean. Students born in earlier months tend to perform better in elementary school. The relative age effect is stronger in the science subjects like mathematics, social science, and natural science compared to language subjects. Interestingly, the effect becomes insignificant in English. A possible explanation for this finding lies in the Korean context. Private tutoring expenditures on English language education are the highest compared to other subjects (Statistics Korea, 2019) and many Korean students study for a year or two in English speaking countries (Statistics Korea, 2018).

Measuring the duration of the relative age effect is also important. Thus, we ran the regressions without pooling the data (cf. equation (2)). Table 6 displays the relative age effect coefficients and test statistics by students' grades and subjects.

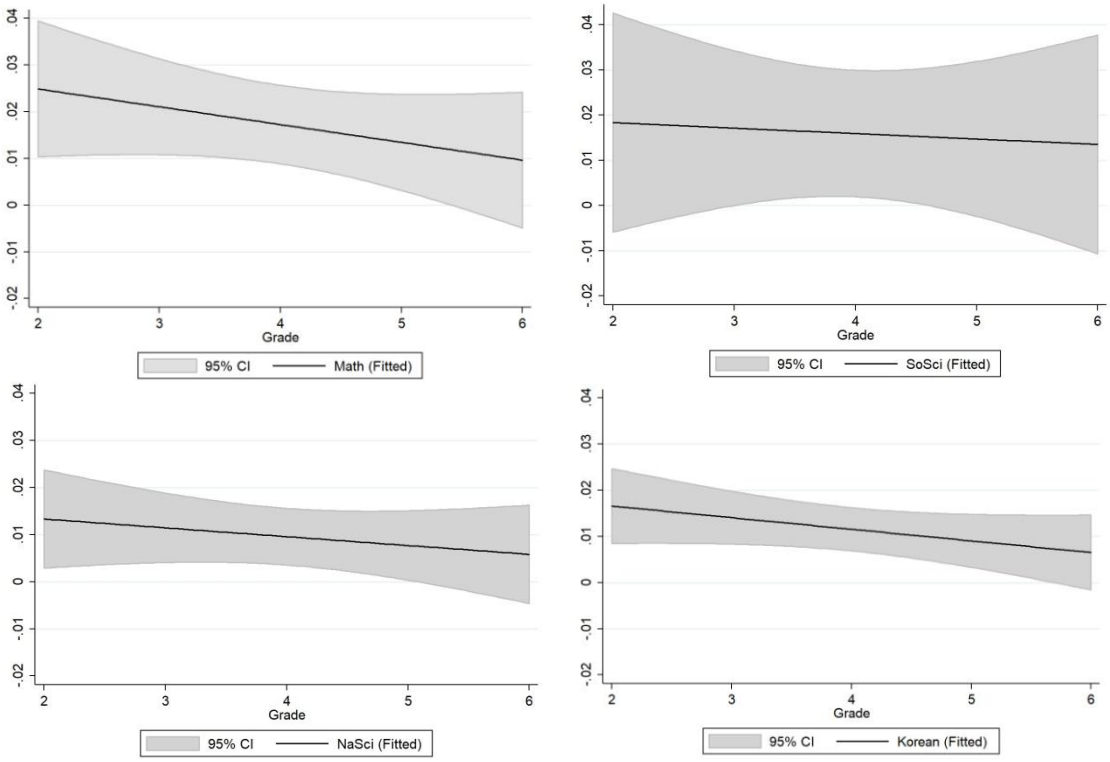
Table 6: Relative Age Effects by Grades and Subjects (OLS Regressions)

Grade	Math	SoSci	NaSci	Korean	English
2	0.023291***	0.010976	0.009726	0.013504*	
	(0.008405)	(0.007469)	(0.007253)	(0.007541)	
3	0.01972**	0.026439***	0.012913*	0.016239**	0.016733*
	(0.008507)	(0.008397)	(0.007763)	(0.00734)	(0.008819)
4	0.025415***	0.021896***	0.015234**	0.015335**	0.002998
	(0.007856)	(0.007887)	(0.007526)	(0.006886)	(0.009033)
5	0.007688	0.004387	0.006585	0.007458	-0.00278
	(0.008477)	(0.008608)	(0.007463)	(0.006883)	(0.009125)
6	0.010262	0.015993*	0.003512	0.005306	0.004409
	(0.008647)	(0.008191)	(0.007654)	(0.006837)	(0.00902)

Note: The same control variables as in the pooled OLS regression are used. Numbers of observations range from 1,524 to 1,668.
Standard errors are in parenthesis
* denotes p<0.10, ** denotes p<0.05, *** denotes p<0.01

A total of 24 ordinary least squares regression results is shown. As can be seen, the relative age effect disappears from the 5th grade for mathematics, natural science, Korean, and English. The relative age effect for 5th grade and 6th grade students is not only statistically insignificant but also small in magnitude. In other words, the relative age effect becomes smaller as students age. Figure 1 illustrates our results graphically. For all subjects except English, the fitted values of the relative age effects are displayed. The illustration highlights the downward trend and the limited duration of relative age effects.

Figure 1: Declining Relative Age Effect



Unlike in other academic subjects, the relative age effect may last longer in the social science field as it is connected with social skills. In her study, Robertson (2011) uses birth quarters to identify the relative age and runs 2SLS regressions. According to Robertson (2011), "higher-level social skills in older students may also affect first birth quarter students' higher achievements" (p. 309). In other words, relatively older students tend to have more profound social relationships that are required to understand the intricacy of social studies such as diplomacy and international relations in history lessons.

The first robustness check is using the seventh grade data from the same cohort. As students entered middle school, the KCYPS included more compact academic performance variables based on their school exam scores. The variables range from 1 to 8 where '1' is assigned to students who scored lower than 65 and '8' is assigned to students who scored higher than 96. Moreover, just like the elementary schools in Korea the middle schools teach the same academic curriculum set by the national government. Therefore, we may give

additional robustness to our estimations for the relative age effect by using the data from grade 7.

Table 7: Robustness Check: Using Seventh Grade Outcomes

Grade	**Math**	**SoSci**	**NaSci**	**Korean**	**English**
7	-0.00107	0.023324	0.023294	0.015895	0.00349
	(0.022303)	(0.020465)	(0.020751)	(0.01898)	(0.021075)
Obs	1,470	1,447	1,469	1,469	1,470

Note: The same control variables as in the pooled OLS regression (cf. Table 5) are used.
Standard errors are in parenthesis
* denotes p<0.10, ** denotes p<0.05, *** denotes p<0.01

As depicted in Table 7, the statistical significance of the relative age disappears in grade 7.

The second robustness check is also using seventh grade students and testing whether 2004 January and February born students perform worse than the regular cohort.[6]

Table 8: Robustness Check: Using 2004 January and February Born Students

Grade	**Math**	**SoSci**	**NaSci**	**Korean**	**English**
7	0.213606	-0.75844**	-0.29551	-0.37548	-0.36065
	(0.402415)	(0.368999)	(0.372541)	(0.341137)	(0.382068)
Obs	1,778	1,751	1,777	1,776	1,778

Note: The same control variables as in the pooled OLS regression (cf. Table 5) are used.
Standard errors are in parenthesis
* denotes p<0.10, ** denotes p<0.05, *** denotes p<0.01

Students who decided to enter school early did not perform worse than the students in the regular cohort except for social science. The negative sign of the relative age effect in social science may be explained by the social skills mechanism discussed before.

For the last robustness check, we use the Tobit regression model. Because the range of the categorical dependent variable is finite, the Tobit regression model is very well suited to the data structure. The lower limit is set to zero, and the upper limit is set to six to avoid a loss of observations in the data. The same sets of control and outcome variables are used. Table 9 displays the 24 Tobit regression results, showing only the relative age effects by

[6] In this regression, we included the 2003 January and February born students.

different grades and subjects.

Table 9: Robustness Check: Relative Age Effects by Grades and Subjects (Tobit Regressions)

Grade	**Math**	**SoSci**	**NaSci**	**Korean**	**English**
2nd Grade	0.023291***	0.010976	0.009726	0.013504*	
	(0.008113)	(0.007209)	(0.007001)	(0.007279)	
3rd Grade	0.01972**	0.026439***	0.012913*	0.016239**	0.016733**
	(0.008175)	(0.008069)	(0.007459)	(0.007054)	(0.008475)
4th Grade	0.025415***	0.021896***	0.015234**	0.015335**	0.002998
	(0.007511)	(0.00754)	(0.007195)	(0.006583)	(0.008635)
5th Grade	0.007688	0.004387	0.006585	0.007458	-0.00278
	(0.0081)	(0.008224)	(0.007131)	(0.006577)	(0.008718)
6th Grade	0.010262	0.015993**	0.003512	0.005306	0.004409
	(0.008249)	(0.007815)	(0.007302)	(0.006522)	(0.008605)

Note: The same control variables as in the pooled OLS regression (cf. Table 5) are used. Numbers of observations range from 1,524 to 1,668.
Standard errors are in parenthesis
* denotes p<0.10, ** denotes p<0.05, *** denotes p<0.01

As can be seen, the Tobit regression results are consistent with the ordinary least squares model (c.f. Table 6). The relative age effect is statistically significant in mathematics, social science, and Korean until the fourth grade, and the duration of the effect in the social sciences is longer than in other subjects. Moreover, the magnitude of the relative age effect is comparably smaller for fifth and sixth grade students.

V. Conclusion

This study makes three main contributions to the relative age effect literature. First, it shows the existence of the relative age effect in the Korean elementary school education by distinguishing five main subjects: mathematics, social science, natural science, Korean, and English. The relative age effect appears in all academic subjects except for English. Second, we measure the duration of relative age effects. Our results which are based on pooled OLS, OLS, and Tobit regressions all show that relative age effects last until the fourth grade except for social science which lasts until the sixth grade. We have argued that relatively older students presumably have a more profound social skill set which might be crucial to grasp the subject matter in social science. Third, we find that relative age effects are bigger in magnitude and have stronger statistical significance for science subjects (Math, SoSci, and NaSci). The language subjects (Korean and English), in contrast, are found to be less prone to relative age effects. We have argued that these results are in line with the idea that language acquisition might be a more naturally occurring phenomenon while the learning of scientific contents requires more cognitive concentration.

An important implication of our results concerns any possible endogeneity issues related to seasonal birth. Based on our results we think that endogeneity issues can be rightfully discarded when conducting empirical investigations that look into the academic performance of middle and high school students. The same must then be true for subsequent outcome measures such as tertiary education and labor market outcomes. In this respect our study is consistent with the findings in Dobkin & Ferreira (2010) and Nam (2014) but contradicts Black, Devereux, & Salvanes (2011), Grenet (2011), and Fredriksson & Ö Ckert (2013). The importance of this implication is not restricted to education research. Policy makers and parents alike need to understand that too strong a focus on putative adverse effects of seasonal births in fact diverts attention from the most important question of all:

given the heterogeneous student body of today how can the learning conditions be set in such a way that as fair and equal opportunities as possible are guaranteed.

VI. References

Baram-Tsabari, A., & Yarden, A. (2010). Quantifying the Gender Gap in Science Interests. *International Journal of Science and Mathematics Education*, 9(3), 523–550. **(o)**

Black, S. E., Devereux, P. J., & Salvanes, K. G. (2011). Too Young to Leave the Nest? The Effects of School Starting Age. *Review of Economics and Statistics*, *93*(2), 455–467.

Crawford, C., Dearden, L., & Greaves, E. (2014). The Drivers of Month-of-birth Differences in Children's Cognitive and Non-cognitive Skills. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *177*(4), 829–860.

Dahl, G. B., & Lochner, L. (2012). The Impact of Family Income on Child Achievement: Evidence from the Earned Income Tax Credit. *American Economic Review*, *102*(5), 1927–1956.

Davies, B. (2004). The Gender Gap in Modern Languages: A Comparison of Attitude and Performance in Year 7 and Year 10. *The Language Learning Journal*, *29*(1), 53–58.

Davis-Kean, P. E. (2005). The Influence of Parent Education and Family Income on Child Achievement: The Indirect Role of Parental Expectations and the Home Environment. *Journal of Family Psychology*, *19*(2), 294–304.

Datar, A. (2006). Does Delaying Kindergarten Entrance Give Children a Head Start? *Economics of Education Review*, *25*(1), 43–62.

Dhuey, E., & Lipscomb, S. (2008). What Makes a Leader? Relative Age and High School Leadership. *Economics of Education Review*, *27*(2), 173–183.

Dobkin, C., & Ferreira, F. (2010). Do School Entry Laws Affect Educational Attainment and Labor Market Outcomes? *Economics of Education Review*, *29*(1), 40–54.

Duncan, G. J., Morris, P. A., & Rodrigues, C. (2011). Does Money Really Matter? Estimating Impacts of Family Income on Young Children's Achievement with Data from Random-assignment Experiments. *Developmental Psychology*, *47*(5), 1263–1279.

Fredriksson, P., & Ö Ckert, B. (2013). Life-cycle Effects of Age at School Start. *The Economic Journal*, *124*(579), 977–1004.

Grenet, J. (2011). Academic Performance, Educational Trajectories and the Persistence of Date of Birth Effects. Evidence from France. Unpublished Manuscript.

Hong, H. J., Kim, D. S., & Byun, J. J. (2010). Relationship Between Student's Born Months and Academic Achievement: 'Monthly Age Effect' on Students Academic Achievement. *Korean Journal of Educational Research*, 48(3), 99–124.

Kawaguchi, D. (2011). Actual Age at School Entry, Educational Outcomes, and Earnings. *Journal of the Japanese and International Economies*, *25*(2), 64–80.

Kim, Y. S., al Otaiba, S., Wanzek, J., & Gatlin, B. (2015). Toward an Understanding of Dimensions, Predictors, and the Gender Gap in Written Composition. *Journal of Educational Psychology*, *107*(1), 79–95.

Korea Ministry of Education. (2015). The Achievement Guideline by Grades.

Lawlor, D. A., Clark, H., Ronalds, G., & Leon, D. A. (2006). Season of Birth and Childhood Intelligence: Findings from the Aberdeen Children of the 1950s Cohort Study. *British Journal of Educational Psychology*, *76*(3), 481–499.

Lee S. J. (2011). The Secret of Outliers' Success: The Effects of Elementary School Entrance Monthly Age on the Academic Ability. *Secondary Education Research*, *59*(3), 813–837.

Nam, K. (2014). Until When Does the Effect of Age on Academic Achievement Persist? Evidence from Korean Data. *Economics of Education Review*, *40*, 106–122.

Puhani, P. A., & Weber, A. M. (2006). Does the Early Bird Catch the Worm? Instrumental Variable Estimates of Early Educational Effects of Age of School Entry in Germany. *Empirical Economics*, *32*(2), 359–386.

Robertson, E. (2011). The Effects of Quarter of Birth on Academic Outcomes at the Elementary School Level. *Economics of Education Review*, *30*(2), 300–311.

Smith, J. (2010). How Valuable Is the Gift of Time? The Factors That Drive the Birth Date Effect in Education. *Education Finance and Policy*, *5*(3), 247–277.

Sprietsma, M. (2008). Effect of Relative Age in the First Grade of Primary School on Long-term Scholastic Results: International Comparative Evidence using PISA 2003. *Education Economics*, *18*(1), 1–32.

Statistics Korea. (2014). 2014 Living Time Survey.

Statistics Korea. (2018). 2017 Private Tutoring Expenditure Survey.

Statistics Korea. (2019). 2019 Primary and Secondary School Private Tutoring Expenditure Survey.

Wang, M. T., & Degol, J. L. (2016). Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. *Educational Psychology Review*, *29*(1), 119–140.

Yun, H. J. (2017). The Effect of Monthly Age on School Adjustment of Elementary Students. *The Journal of Elementary Education*, *30*(4), 105–128.

Books

Fromkin, V., Rodman, R., & Hyams, N. (2014). *An Introduction to Language*, (10th ed). Wadsworth Cengage Learning.

Ohasi, K. (2006). *Language in Society: Critical Themes and Perspectives no*. Natural English Works