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# Does School Accountability Reduce Inequality in Education? Lessons from South Korea

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**Abstract**

This study takes note of changes in school accountability policies from 2009 to 2015 in Korea utilizing OECD PISA data from 2006 to 2015. We found that active implementation of the accountability policy (2009-2012 period) were effective in raising the academic performance of students and schools in the lowest socioeconomic strata. However, when the school accountability policies were gradually abolished (2012-2015), education achievements of students from poor family background as well as the overall performance of low achieving public schools worsened significantly. We particularly noted that it was only public schools that experienced gains and exacerbations in school performance in accordance with the status of accountability policy, conversely, private schools somewhat gained from the implementation of the policy and resisted negative consequences following the gradual abolishment of the policy.

## 1. Introduction

Education has long been regarded as an important means to achieve upward social mobility in Korea, but the confidence of Koreans over equal access to quality education has been seriously weakened in recent years (Byun & Kim, 2010; Koo et al., 2016), and especially youth in Korea no longer believes that they can rise through the social ladder with efforts and education alone (Kim, 2015). Considering that negative perceptions on social mobility is detrimental to the life satisfaction (Alesina, Tella, & MacCulloch, 2004; Fischer, 2009) and can lead to social conflicts and difficulties in achieving social cohesion (Green, Preston, & Sabates, 2003; Jo, 2016; Yeo et al., 2015), resolving the negative beliefs of youth would have far reaching consequences for the society as a whole. Nevertheless, it is remarkable how consistently important the family's background has been for children's education achievements in Korea over the last few decades (Park, 2007).

School accountability has been noted as an important policy device that can play a critical role in reducing educational achievement inequality. Various studies exploring the impact of the No Child Left Behind policy in the United States have reported a range of positive effects of accountability policies in raising academic achievements of students, especially for those with low academic achievement and those from poor family backgrounds (e.g., Carnoy & Loeb, 2002; Dee & Jacob, 2011; Hanushek & Raymond, 2005; Jacob, 2005; Ladd & Lauen, 2010; Springer, 2008). More recently, utilizing the data of 59 countries in OECD Program of International Student Assessment (PISA) conducted from 2000 to 2015, Bergbauer, Hanushek and Woessmann (2018) also found that accountability policies of expanding standardized external comparisons in general is associated with improvement in student achievement.

Nonetheless, there are still ongoing debates about the effectiveness of school accountability policies. To this end, Korea's rapid shifts in the accountability policy makes it ideal for the test of the efficacy of the policy. More specifically, school accountability policies in Korea underwent several changes within a relatively short period of time. Korea first implemented the accountability policy in 2008 in the form of national testing of all students in sixth, ninth, and tenth grades and publicly announced the results. Then, later in 2009, the Korean government started supplementary policies aimed at providing various aids to the vulnerable schools identified by the national testing. However, the accountability policies were gradually abolished from 2013 with the change of government administration. Interestingly, these periods of implementation and subsequent withdrawal of the accountability policy coincided well with the PISA test periods. Thus, exploiting the rapid changes of policies in Korea as a form of a natural experiment, it would be possible to assess whether and how school accountability policies promote equality of education. For this empirical investigation, this study will utilize the four recent rounds of the PISA conducted from 2006 to 2015 in 3-year intervals. The PISA data are internationally comparable education achievement data of 15-year-old students across OECD and participating nations. Using the dataset, this research will display effectiveness of school accountability policies in improving academic performance of students from poor family backgrounds and low achieving schools with particular emphasis on differences in the impact between public and private schools.

Rest of the chapters are organized as follows. Section 2 reviews literature on education inequality, accountability policy and institutional background in Korea. Section 3 presents descriptions of the empirical model utilized in the study, and section 4 reports findings from the

empirical analyses. Finally, section 5 and section 6 present robustness check and conclusions, respectively.

## 2. Education Achievement Inequality

When examining inequality in education achievement, it is important to consider various contributing factors. In simple terms, elements determining an individual's education achievement can be divided into factors within the boundary of self-control (e.g., effort and diligence) and those outside, such as family background as well as school and policy factors (Hanushek & Woessmann, 2011). From this perspective, equality of education is closely linked to the concept of fairness in education opportunity or to the extent that academic achievement of students is not being influenced by factors outside of one's self-control such as one's family background (Ferreira & Gignoux, 2013). In general, family background refers to a broad concept encompassing various socio-economic elements such as household income, social status, and education level of parents, and this has been noted as one of the key influential factors determining education achievement of students across a number of countries (Hanushek & Woessmann, 2011; Sirin, 2005). This is also certainly true in Korea as well. Various studies in Korea have shown that children from better family background generally receive better grades and enter more prestigious universities (Byun & Kim, 2008; Kim et al., 2015; Jang & Kim, 2015), and those who have received better education tend to have better life opportunities and incomes in the future (Jung & Lee, 2016). From the social perspective, such differences in life outcomes due to unequal opportunities in education is a significant factor that may eventually lead to social unrest and discontent (Alesina & Perotti, 1996), and may have negative

consequences for general well-being and cohesion of the society as a whole. Furthermore, with the onset of the Fourth Industrial Revolution (or Industry 4.0), it is expected that traditionally labor intensive and manufacturing jobs will be replaced by automation and artificial intelligence (Frey & Osborne, 2013). This means that it will be even more important to provide general education of higher standard to all citizens in the future to better face the upcoming challenges. As such, being able to guarantee an education system that ensures fairness in opportunity is a critical concern for any society.

### *2.1. Education Inequality, Accountability, and School Ownership*

To a large extent, level of educational inequality of a nation is inherently linked to its education policies. Among myriad of education policies, school accountability policies have been of particular interest to educationalist and policy makers in recent years. Although school accountability policy is a broad concept that could be defined in various ways, there are two distinguishable types. First is the report-card accountability, which measures schools with standardized tests and publishes test results to general public to gain transparency without attaching other explicit stakes to the results. While no enforcement is made on schools to change their management practices, publication of information alone can affect behaviors of parents and students, and as long as these stakeholders respond to the published information, the report card accountability system can indirectly induce schools to act accordingly (Deming & Figlio, 2016; Nunes, Reis, & Seabra, 2015). Another commonly adopted accountability system is the consequential accountability system that links the responsibilities for the results of standardized tests to teachers and to schools (Deming & Figlio, 2016). In other words, the consequential

accountability is the report-card accountability with explicit high-stakes or incentives attached and is a more typical approach through which governments implement their accountability policies. As for incentives (or disincentives) of the consequential accountability policies, it could include both rewards and punishments such as budgetary supports or closing down of schools based on whether schools performed above predefined criteria, or the system could even attach salary or bonus of each teacher to education achievements of students (Figlio & Loeb, 2011). In this way, through rewards and punishments, the accountability policy attempts to induce schools to autonomously raise their education quality.

A well-known case of the consequential accountability policy is the No Child Left Behind (NCLB) act that was in place from 2002 to 2015. While there are studies reporting little impact of school accountability policies on improving academic achievement of students (Figlio & Loeb, 2011; Fuller et al., 2007; Rockoff & Turner, 2010), there also exist a number of studies that suggest significantly positive impacts on achievements of students (Carnoy & Loeb, 2002; Dee & Jacob, 2011; Hanushek & Raymond, 2005; Jacob, 2005). In particular, there appears to be sizable evidence for positive impact of accountability policy in reducing achievement inequality. Dee and Jacob (2011) utilized state-level panel data to show that NCLB resulted in general increase in fourth grade math achievement, and more importantly, students (in fourth and eighth grades) from disadvantaged background also gained from the accountability policy. Likewise, Carnoy and Loeb (2002) found that accountability policy had positive impacts for black and Hispanic students who tend to come from more socially disadvantaged background than white students in comparison. In general, there are a number of studies showing positive improvement for low performing students (Ballou & Springer, 2008; Ladd & Lauen, 2010), indicating that

accountability policy could ameliorate achievement inequalities due to differences in socioeconomic background of students.

Such positive effect, however, could be conditional upon a number of factors. Firstly, resource availability appears to be an important element for effective accountability policy. Gaddis and Lauen (2014) presented results that more affluent schools were better able to respond to accountability pressures by reducing the black-white achievement gaps. Likewise, a study examining the effect of abolishment of report card accountability system showed similar outcomes. Burgess, Wilson, and Worth (2013) investigated the removal of accountability policy in Welsh schools, and their study indicated that students in Welsh schools performed significantly worse than students in English schools after the abolishment of the accountability system in Wales. Crucially, this negative effect of abolishment was only relevant for poor and low performing schools while the highest performing and affluent schools were unaffected by the abolition of the policy. Overall, these results show that resource availability of schools is an important component that facilitates reduction of education inequalities when accountability policy is in place.

Secondly, it is important to consider how stakeholder (constituting actors) behaviors change in response to the policy, and its relations with respect to the organizational structure of schools. There is evidence that when accountability pressure is high and when performance is tied to punishment, such as in the NCLB policy, teachers tend to concentrate on improving students near the proficiency borderline (Jennings & Sohn, 2014; Reback, Rockoff, & Schwartz, 2014), meaning that students at the lowest end may be neglect. Indeed, qualitative survey and interviews of teachers in failing schools responded that they strategically focused on borderline

students to raise schools' overall performance ratings (Hamilton et al., 2007). However, such strategic behaviors could manifest differently depending on structural organization of schools.

First to consider is the qualitative differences in teachers as a result of the organizational differences between public and private schools. It has been shown that, on average, private school teachers are more intrinsically motivated and creative than public school counter-parts (Fidan & Ozturk, 2015), which are also known to predict quality of performance in organizations (Cerasoli, Nicklin, & Ford, 2014). Moreover, compared to public school teachers, more private school teachers are satisfied with their school climate and jobs, identify with their schools, have greater organizational commitment, and believe that they act responsibly in terms of meeting teaching performance requirement (Hannaway, 1991; Honingh & Oort, 2009; Reyes & Pounder, 1993). These set of evidence indicate that teachers in private schools are more apt at adapting to changing environments and pressures, such as when accountability pressures are high, than public school counterparts. Influencing the teacher characteristics, however, is the management practice of schools and leadership of school principals.

From the school-level perspective, private and public schools show distinguishable characteristics. Private schools in general have greater freedom over personnel management, and this relative freedom can act as a useful resource in the face of accountability pressure. It has been shown that the key efforts of principals who successfully endeavored to transform schools were reducing teacher turnovers and raising overall quality of newly in-coming teachers (Dizon-Ross, 2018). Likewise, turnover of (and consequent replacement of) low-performing teachers raises overall achievement of students especially in high poverty schools (Adnot, Dee, Katz, & Wyckoff, 2017). This means that freedom over staff management plays an important strategic part in responding to the accountability threat for schools and principals. Furthermore,

differences in school climates between public and private schools could also act as a facilitator of accountability policy. Cross-nationally, private government-dependent schools tend to outperform public schools even after accounting for social compositional differences, and this has been attributed to relatively better school climate of private government-dependent schools (Dronkers & Robert, 2008). Importantly, positive school climate is a factor that can reduce teacher stress and job dissatisfaction (Collie, Shapka, & Perry, 2012; von der Embse, Pendergast, Segool, Saeki, & Ryan, 2016) and can raise higher teacher expectation on students (Brault, Janosz, & Archambault, 2014), which can causally raise academic outcomes of students (Rubie-Davies, Peterson, Sibley, & Rosenthal, 2014). Considering these facts, private schools appear better positioned than public schools in facing the accountability threat, which is known to cause worsen school climate and teacher stress (von der Embse et al., 2016).

As a whole, it seems likely that private schools can better manage the pressures of accountability policy and generate expected positive outcomes. As will be explained in later sections, specifically in Korean context, these aforementioned aspects of school types can have even greater differentially impact on how accountability policy is adopted in schools and on subsequent achievement of students due to unique nature of Korea′s public teacher placement policy.

### *2.3. Institutional Backgrounds*

Korea's school system is characterized by its dedication to ensuring equity in education. Many aspects of school system including curriculum and management are standardized so that relatively little difference exists between public and private schools in Korea (Park, Byun, &

Kim, 2011). This was the result of government's drive to curb excessive shadow education in the 60s and 70s, removing the Middle School Entrance Exam and randomly allocating students to public or private school located within their school district (Lee, Lee, & Jang, 2010). This was only possible because the government equalized the differences between public and private schools by subsidizing and regulating curriculum and school operations such as teacher salary and finances. Nevertheless, important differences exist between the two school types. Most notably, private schools in Korea have flexibility over hiring and promotion of teachers and principals who, therefore, have less job security than public school counter parts and are held more accountable than those in public schools. For example, contract teachers in private schools, who have the potential opportunity to become permanent teachers in private schools, positively affect academic achievement of students while those in public schools, who do not have the same opportunity, have negative influences on student performance (Cho, 2013). Similarly, Choi (2014) report that although contract teachers negatively affect school performance, the effect is far less negative in private schools. Thus, private school staffs tend to have more inherent drive to perform than public school teachers.

Another important difference between public and private schools is the stability of staff composition. In contrast to teachers and principals in public schools who rotate to different schools every four years, private school teachers and principals can stay in the same school as long as the school board approves of their appointment. This means that private school teachers can accumulate experience for and develop cultural norms and know-hows of their specific schools and can form a more coherent teaching structure (Kim, 2008). In the same way, since promotions in private schools are rather limited, private school teachers are relatively free from unnecessary competition between teachers and can spend their energy more on teaching (Kim,

2008). Similarly, in public schools, school policies that teachers and principals actively pursue lose their momentum once the person in charge leaves the school. In comparison, because private school teachers and principals tend to stay within one school, schools can better able to maintain consistency and continuance of already employed school policies and can also implement policies from the long-term perspective. Moreover, due to long-term employments within schools, private school teachers form tighter community and put more efforts in maintaining better school climates and inter-teacher relationships than public school teachers, who would leave for other schools in few years (Kim, 2008). Thus, these the differences in governance structure between public and private schools can critically elicit different adaptive behaviors to accountability policy that could manifest more successfully in private than public schools.

As for the history of school accountability policy in Korea, it dates back to May 31, 1995 when the Presidential Commission on Education Reform (PCER) made a number of reforms to K-12 education (Lee & Park, 2014). Included in its changes was tying financial and administrative support to performance of districts and their schools, which then led to the establishment of a legal foundation in 1997 (Article 9 of the Elementary and Secondary Education Act) for implementing nation-wide assessment of academic achievement of students (Song & Park, 2015). Subsequently in 1998, the national assessment started with small sample of student (grade 6, 9, and 10), and it gradually expanded till 2007, reaching 3% samples for elementary and middle schools and 5% sample for high schools in the nation (Song & Park, 2015; Yi, 2015). This policy, however, received criticisms over its inherent limitations as a sampled survey in being able to identify academically troubled students and accountability of individual schools. Consequently, it was most noticeably reinforced during the Lee Myung-bak administration in 2008. The free market approach to education by providing choices while

encouraging competition was the key principle governing public education under the Lee administration (Lee, 2012). As a result, greater attention was paid to accountability, autonomy, and diversity in public education at the time, and although the accountability policies of Lee administration were fiercely opposed by teachers and their union, arguing that autonomy and accountability driven policies would exacerbate education inequality (Lee, 2012), the National Assessment of Educational Achievement (NAEA) became a population-wide assessment at the beginning of Lee administration. Indeed, one of its key pledge during the election was "Plans for Zero Underperforming Students," and the population-wide NAEA was a crucial element in realizing the plan. This occurred in conjunction with public reporting of scores of all participating schools to stress accountability in schools and education in general. In addition to the population-wide assessment, another standout feature of Lee administration's accountability policy was in providing financial assistance to underperforming schools identified by the national assessment. This program was known as the School for Improvement program, which later became the Creative Management School project. More specifically, schools with above minimum threshold of underperforming students (5%, 20%, and 40% for elementary schools, middle and general high schools, and non-general high schools, respectively) were mandatorily assigned to the project and received financial assistance ranging from 50 to 100 million won[1], which schools could use autonomously in various ways to improve their performance such as hiring extra assistant teachers, providing after-school lessons, or seeking consultations on overall workings of the school (Woo, Lee, & Kim, 2015). With the onset of Park Geun-hye administration in 2013, however, education discourse changed to emphasizing creativity and, in particular, happiness in education. This led to withdrawal of the NAEA for sixth grade elementary school students. Although it was certainly true that the NAEA for third grade middle

[1] 50 million won is about $46,400 dollars when converted with 1077.62 won per dollar.

school students and second grade high school students were maintained, the budget for the School for Improvement program, which was the key component of the accountability policy, declined significantly from 247 billion won in the period 2009-2012 to 15.8 billion won in the period 2013-2014. Furthermore, in the country-wide elections for education superintendent of each province in June 2014, 13 elected superintendents out of possible 17 positions were so-called liberal superintendents who had a clear stance against the school accountability policies such as promoting abolishment of remaining NAEA for middle and high schools. All in all, the general interests in the school accountability were drastically reduced in Park administration (Song & Park, 2015). Overall time line of the development of accountability policy in Korea is presented in Table 1.

**Table 1. Timeline of Development of Guaranteeing Basic Achievement Level Policy**

| Time of Introduction | Details of policies introduced |
|---|---|
| Early adoption period from 1997 to 2007 | 1997: Implementation of school-level guidance efforts for students with low academic performance in conjunction with provincial and local education offices<br>July, 1997: Establishment of basic plans for implementation of the Accountable Instruction for Basic Learning Skills<br>2000: Start of the National Assessment of Educational Achievement using sample-level survey methodology |
| Maturation period from 2009 to 2012 | 2008: Start of the "Plans for Zero Underperforming Students"<br>2008: Start of the National Assessment of Educational Achievement using population-level survey methodology<br>June, 2009: Planning and implementation of the School for Improvement<br>2011: Support for students who academically underperform due to emotional and behavior disorders<br>2011: Support for remaining schools[2] and borderline schools<br>February, 2011: Establishment of basic plans for implementing creative management school project |
| Modification period from 2013 and present | 2013: Complete withdrawal of the National Assessment of Educational Achievement for elementary school<br>2017: Replacement of the population level National Assessment of Educational Achievement for middle and high schools to the sample level assessments |

*Source*: Song & Park (2015). Ministry of Education (2017).

[2] Schools that could not stay below the underperformance threshold for consecutive two years

The Korea's school accountability policy was a variation of consequential accountability system. To discover low achieving students and to raise their education outcomes, the NAEA were conducted for every sixth-grade elementary school student, third-grade middle school student, and second-grade high school student (tested first grade high school students only in 2008 and 2009) in the nation since 2008 with the results first publicly announced in 2009 in accordance with the Act on Special Cases Concerning the Disclosure of Information by Education-Related Institutions. Interestingly, Korea's accountability system differed from the NCLB in that rather than punishing schools based on the results of the tests, schools with high proportion of underperforming students (thresholds were 5% and 20% for elementary and middle/general high schools, respectively) were provided with various supports, such as provision of programs from other School for Improvement participants that were rated as outstanding, construction of improvement system for underperforming students, consultations, financial supports, by the government and by respective regional office of education to raise their competency (Lee, 2012; Woo, Lee, & Kim, 2015). Importantly as well, announcement of the results to publics was a key performance motivation for schools as it indirectly created peer- and parental pressures. All in all, the school accountability program in Korea was the consequential accountability system that focused more on identifying and providing necessary resources to schools with significant needs.

Whether an accountability policy emphasizing identification of and support for weak schools raises equality of education is still an area that requires more active research in Korea. One of few studies that have examined the topic suggested that School for Improvement policy that was implemented in conjunction with the NAEA reduced the share of underperforming

middle school students by 18% in 2010 compared to 2009 (Woo, Lee, & Kim, 2015). This means that the School for Improvement policy, which mostly targeted students below the national standard, had considerable impact in reducing the number of low performing students. Likewise, Cha and Min (2013) used the 2010 Seoul Educational Longitudinal Study data to reach a similar conclusion in that the School for Improvement policy was able to reduce the achievement gap of low performing students in Seoul. Furthermore, it has even been shown that this policy can also affect higher performing students through peer effect, increasing the share of above average achieving students by 5% point for every percentage point decrease in the share of underperforming students (Woo, 2016). The accumulating evidence seems to indicate that the impact of Korea′s accountability policy is rather positive.

Nonetheless, it is less clear whether the policy effect would remain in place once it is removed. Furthermore, accountability policy may have differential effects depending on school types and across socioeconomic strata. Therefore, this research attempts to clarify effects of introducing and removing accountability for students from low socioeconomic status in public and private schools. Firstly, it may be expected that students from low socioeconomic status may gain relatively more from the accountability policy in Korea since low performing students tend to come from poor family background. Importantly, it is predicted that both public and private schools will benefit from the accountability and supportive policy when it is introduced, but that only private schools will be able to retain the positive effects of the policy when it is removed since private schools inherently have more coherent structure that can maintain the momentum of positive changes.

## 3. Methodology and Data

In comparison to the previous researches that utilized tests scores based on specific curricula, this research employs PISA test scores–international assessments of student achievement–to empirically confirm the impact of school accountability in reducing achievement inequality. In contrast to the College Scholastic Ability Test (CSAT) or the NAEA, which assesses students based on school curricula, PISA is designed to assess whether students possess capacities required to meet daily demands of adult lives (Fuchs & Woessmann, 2007). This means that PISA is more closely related to evaluation of true cognitive abilities than the CSAT. For instance, it was reported that preparing students for PISA tests has minimal impact on their PISA scores (Brunner, Artelt, Krauss, & Baumert, 2007), and even when countries are scored based only on questions deemed the most appropriate for curriculum of respective countries during the development phase of the PISA tests, overall score ranks did not fluctuate much (Adams, Berezner, & Jakubowski, 2010), indicating that PISA tests results are quite independent of curricula and that the tests may be more valid assessments of cognitive abilities than tests purely based on school curriculum. In addition, one other advantage of PISA test is the standardization of target group to 15-year-old students rather than sampling based on certain school grade, which may differ depending on nations. This choice enables greater generalizability of the obtained results to international context. Therefore, the PISA datasets were chosen in this study to investigate impact of Korea's accountability policy. The key periods of interest in the PISA dataset were 2006, 2009, 2012, and 2015. More specifically, 2006 and 2009 represent years when the accountability policy was not fully in place.[3] As for 2012, it was the year when the full

3 2009 is the year when financial support began in line with the announcement of the first assessment results of the National Assessment of Educational Achievement.

effect of school accountability policy was taking place.[4] Finally, 2015 was when the school accountability policy was, in effect, removed from the government agenda.

Using the data covering a range of time-periods, difference-in-difference analysis could be conducted to test the effect of pre-existing trend as well as introducing and removing the school accountability policy. Firstly, in order to test for the effect of accountability policy on the inequality of opportunity at the individual-level, a number of difference-in-difference analyses were performed. At the individual-level, the treatment group in each analysis was defined as the bottom quintile group in terms of socioeconomic family background.[5] Moreover, at the school-level, the treatment school was defined as those below median level of school socioeconomic status, which was calculated by averaging the level of socioeconomic status of sampled students in each school. Dependent variables in analyses were PISA subject scores and level 1 achievement status of students. To explain the level 1 status in more detail, the OECD (2010) categorizes PISA scores into six proficiency ranges, and among them, OECD defines the level 2 proficiency[6] as having achieved the minimum level of knowledge required to "participate effectively and productively in life." As such, it can serve as a potential indirect indicator predicting future inequalities in life arising from differences in early education achievements

[4] The population-wise National Assessment of Educational Achievement was first conducted in October 14-15, 2008, and its results were announced in February 16, 2009.

5 Although the defined target of the school accountability policy was underperforming students in schools with high portion of low achieving students to be specific, as was confirmed in previous literatures, poorer the family background of students, worse their education achievement, meaning that the policy implemented at the school or education office level naturally focused on students with poor family background. Therefore, assuming that the school accountability policy was aimed at the bottom 20% of the socioeconomic status (based on ESCS index values) should not be problematic.

[6] For mathematics, the cut-off point for level 1 proficiency was less than 420. For science, it was less than 410. For reading, the cut-off was less than 407.

(Balcazar, Narayan, & Tiwari, 2015).[7] The general model used for each difference-in-difference analysis is shown in the Equation 1.

$$y_{ist} = \beta_0 + \beta_1 Period_t + \beta_2 Bottom_i + \beta_3 Second\ Quintile_i + \beta_4 Fourth\ Quintile_i + \beta_5 Top_i + \beta_6 (Period * Bottom)_{it} + \beta_7 (Period * Second\ Quintile)_{it} + \beta_8 (Period * Fourth\ Quintile)_{it} + \beta_9 (Period * Top)_{it} + I_{it}\alpha + S_{st}\gamma + \epsilon \quad (1)$$

Here, $y_{ist}$ is PISA plausible values of each subject (science, mathematics, and reading) for each individual $i$ in school $s$ in time $t$.[8] $Period_t$ is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2015 for the 2012-2015 analysis. $Bottom_i$, $Second\ Quintile_i$, $Fourth\ Quintile_i$ and $Top_i$ are dummy variables indicating socioeconomic status of individuals with the *Bottom* and *Top* being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. As for $(Period*Bottom)_{it}$, $(Period*Second\ Quintile)_{it}$, $(Period*Fourth\ Quintile)_{it}$, and $(Period*Top)_{it}$ variables are interactions of aforementioned variables. For control variables, $I_{it}$ and $S_{st}$ are vectors of individual- and school-level variables in time $t$, respectively.[9] This model has been analyzed with differing dependent variables for the total of six variations in each

[7] For instance, students with level 2 reading proficiency were much more likely to study higher education than those with level 1 reading proficiency, and those with higher proficiency tend to earn greater income (Schleicher, 2010). Likewise, higher proficiency at age 15 is related to better general educational outcomes and attainments in the future (Fischbach, Keller, Preckel, & Brunner, 2013).

[8] The number of plausible values from PISA 2000 to 2012 had been five, but in 2015, the number was increased to 10. Therefore, for the difference-in-difference analysis involving PISA 2012 and 2015 period, five extra plausible values were created for the PISA 2012 data by copying plausible value one through five for each subject. In this way, it was possible to match 10 plausible values of PISA 2015 dataset and conduct the analysis using the full information.

[9] For individual-level controls, age, sex (1=female, 0=male), current school grade (each dummy variable indicating grade 7 through 13; reference group is grade 10), immigrant status (1=immigrant, 0=native), and language used at home (1=Korea,0=other language) were included. For school-level controls, school size, female student ratio, student to teacher ratio, location of school (each dummy variable indicating town, city, and large city; reference group is village/small town), and short of teaching materials (each dummy variable indicating none at all and a lot with very little/to some extent being the reference group).

analysis period: three times with score of each subject and another three times with a dummy variable indicating level 1 proficiency status of an individual in each subject.[10] Furthermore, other factors of interest were the school socioeconomic status, which could affect probability of assignment to the School for Improvement program, and school ownership status, which could influence responsiveness of schools to the accountability policy. Hence, to examine potential differences in responses to the accountability policy due to school ownership status and socioeconomic status of schools, subsample analyses were also conducted. The four subsamples were a) public low socioeconomic status school students, b) public high socioeconomic status school students, c) private low socioeconomic status school students, and d) private high socioeconomic status school students. The above six analyses were conducted for each subsample.

## 4. Results

### *4.1. Descriptive Statistics*

Table 2 presents descriptive statistics of data employed. It can be seen that school size was reduced in 2012 and 2015. In line with this, student to teacher ratio also declined somewhat in the same period. Conversely, average socioeconomic status of students improved across the periods such that the average socioeconomic status of students was about twice as high in 2015 as that in 2006. Another notable point is that 2012 saw some reduction in teaching material shortage while there was dramatic increase in the teaching material shortage in 2015.

**Table 2. Descriptive Statistics from 2006 to 2015**

[10] In the case of difference-in-difference analysis involving level 1 proficiency status of each subject for each student, each analysis uses linear probability estimation rather than OLS estimation.

| | 2006 | 2009 | 2012 | 2015 |
|---|---|---|---|---|
| Age | 15.76(0.29) | 15.7(0.29) | 15.71(0.29) | 15.71(0.3) |
| Female | 0.49(0.50) | 0.47(0.50) | 0.47(0.50) | 0.48(0.50) |
| Grade 10 | 0.97(0.16) | 0.95(0.22) | 0.94(0.24) | 0.90(0.29) |
| Grade 11 | 0.02(0.14) | 0.04(0.2) | 0.06(0.24) | 0.09(0.29) |
| Grade 12 | 0.01(0.08) | 0.01(0.09) | 0.002(0.05) | 0.005(0.07) |
| Immigrant | 0.003(0.05) | 0.004(0.06) | 0.003(0.05) | 0.004(0.06) |
| Korean Used at Home | 1.00(0.03) | 1.00(0.03) | 1.00(0.02) | 1.00(0.06) |
| ESCS | -0.38(0.76) | -0.24(0.73) | -0.13(0.7) | -0.20(0.68) |
| Private School | 0.46(0.04) | 0.37(0.04) | 0.47(0.04) | 0.50(0.04) |
| School Size | 1124.54(12.54) | 1156.88(23.31) | 1074.41(19.08) | 944.27(14.27) |
| Proportion of Female Students at School | 0.49(0.03) | 0.47(0.02) | 0.46(0.02) | 0.48(0.01) |
| Student to Teacher Ratio | 16.35(2.52) | 17.21(3.55) | 16.11(3.79) | 15.09(2.94) |
| School in Small Town | 0.05(0.21) | 0.07(0.26) | 0.06(0.24) | 0.04(0.19) |
| School in Town | 0.10(0.30) | 0.07(0.26) | 0.08(0.26) | 0.11(0.31) |
| School in City | 0.85(0.36) | 0.86(0.35) | 0.86(0.35) | 0.85(0.35) |
| Teaching Material Shortage – Not at all | 0.50(0.50) | 0.38(0.49) | 0.43(0.49) | 0.15(0.35) |
| Teaching Material Shortage – A Little | 0.35(0.48) | 0.40(0.49) | 0.41(0.49) | 0.35(0.48) |
| Teaching Material Shortage – Somewhat/A Lot | 0.15(0.36) | 0.22(0.41) | 0.16(0.37) | 0.50(0.50) |
| Number of Observations | 5,176 | 4,989 | 5,033 | 5,581 |

*Sources*: Calculated by authors based on OECD PISA data.

*4.2 Difference-in-Difference Analyses for Policy Effects on Low Socioeconomic Status Students*

As can be seen in Table 3, the results of the analyses generally confirmed the expectations. Looking at the results by each analysis period, between 2006 and 2009, across all subjects, scores of the bottom 20% group in terms of socioeconomic status declined significantly with respect to the third quintile group in 2009 compared to 2006. In contrast, between 2009 and 2012, the scores of the bottom 20% group across the three subjects in comparison to the third quintile group did not show the same declines that were observed in 2006 to 2009 period. However, in the 2012 to 2015 period, performances of the bottom socioeconomic group worsened again in 2015 compared to 2012 as their science scores showed significantly greater decline than those of the third quintile group in the same period. Overall, the general pattern of results is such that the performance of the bottom 20% became relatively worse in 2009 compared to 2006, but then the decline largely stopped in 2012 compared to 2009. Finally in 2015, the performance deteriorated

again significantly. In other words, during the period in which the school accountability was being implemented, the education achievements of students in the bottom 20% of socioeconomic status reversed their declining trends of the past to maintenance or general recovery, but their education achievement worsened between 2012 and 2015 when the school accountability policy was gradually abolished, exacerbating the inequalities in education opportunity.

Likewise, the difference-in-difference analyses with level 1 proficiency statuses of PISA subjects as shown in Table 3 indicate that probability of being level 1 proficiency status for students in the bottom 20% of socioeconomic status somewhat declined for the science subject during the period in which the school accountability policy was implemented (2009-2012). However, the probability significantly increased again for all three subjects during the period of abolishment (2012-2015). More specifically, for students in the bottom 20% of socioeconomic status compared to those in the middle group, the results suggested that their probability of being level 1 proficient in reading is 5.7% point higher in 2009 than in 2006. As for the case comparing 2009 and 2012 periods, students in the bottom 20% in socioeconomic status were 4.9% point less likely to become level 1 proficient in science than the middle group student in 2012. Conversely, for the period between 2012 and 2015, students in the bottom 20% of socioeconomic status experienced 8.8% point, 8.8% point, and 5.2% point increases in probability of being level 1 proficient in mathematics, science, and reading respectively.

All in all, empirical analyses showed generally exacerbated equality of education opportunity in recent years. The evidence presented indicated that the students in the bottom 20% of socioeconomic status improved both in terms of mean scores and probability of not being level 1 proficient in PISA subjects when the NAEA and the School for Improvement policy were in active

implementation, but when the school accountability policies were gradually abolished (2012-2015), their education achievements, as seen by the aforementioned two indicators, worsened as a result.

**Table 3. Difference-in-Difference Regressions from 2006 to 2015**

| | | | Mathematics (1) | Science (2) | Reading (3) |
|---|---|---|---|---|---|
| 2006-2009 Period *N* =9,932 | Score | Period | 4.015(9.084) | 22.919(8.182)** | -6.517(7.570) |
| | | Bottom | -11.029(4.775)* | -9.699(4.616)* | -5.178(4.255) |
| | | Period x Bottom | -14.715(6.695)* | -12.580(6.784)+ | -14.987(5.791)** |
| | Level 1 | Period | -0.019(0.025) | -0.065(0.017)*** | -0.024(0.018) |
| | | Bottom | 0.025(0.019) | 0.025(0.018) | -0.001(0.017) |
| | | Period x Bottom | 0.038(0.031) | 0.023(0.027) | 0.057(0.024)* |
| 2009-2012 Period *N* =9,739 | Score | Period | 11.151(9.041) | 0.833(7.619) | -1.728(7.272) |
| | | Bottom | -26.932(4.335)*** | -24.87(4.366)*** | -22.031(3.884)*** |
| | | Period x Bottom | 1.115(6.601) | 7.856(5.944) | -0.193(6.172) |
| | Level 1 | Period | 0.007(0.024) | 0.009(0.017) | 0.033(0.021) |
| | | Bottom | 0.068(0.02)*** | 0.059(0.019)** | 0.058(0.018)** |
| | | Period x Bottom | -0.037(0.029) | -0.049(0.027)+ | -0.027(0.032) |
| 2012-2015 Period *N* =10,400 | Score | Period | -26.730(6.952)*** | -21.252(6.122)*** | -17.003(6.726)* |
| | | Bottom | -26.681(4.825)*** | -17.462(3.751)*** | -22.438(4.786)*** |
| | | Period x Bottom | -9.335(6.632) | -11.400(5.312)* | -5.606(6.775) |
| | Level 1 | Period | 0.044(0.018)* | 0.060(0.018)*** | 0.047(0.018)* |
| | | Bottom | 0.031(0.017)+ | 0.009(0.014) | 0.031(0.019) |
| | | Period x Bottom | 0.088(0.028)** | 0.088(0.024)*** | 0.052(0.029)+ |

*Note*: All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method. Detailed table shown in Appendix A.

### *4.3 Difference-in-Difference Analyses for Policy Effect on Low Socioeconomic Status Students by School Types and School Socioeconomic Status*

It was also predicted that the effect of accountability policy may differ by school types and by average level of socioeconomic status of school's student body. A total of four separate sets of analyses were performed for subsamples of students attending either low or high socioeconomic status schools in public or private school settings.

The results of analyses for public and private school students in low socioeconomic status schools are shown in Table 4. First, concerning the results of public school case, overall pattern

of results generally confirms the expected effects of school accountability on academic performances of students from poor family background. More specifically, it is notable that during to 2006-2009 period, academic achievements of students from the poor family background in public schools became significantly worse in all three subjects with respect to the outcomes of the students from middle class background. This means that poorest students attending low socioeconomic public schools were relatively disadvantaged before the start of the school accountability policy.

The negative trend in the 2006-2009 period, however, was somewhat reversed in the 2009-2012 period when the school accountability policy was introduced. The relative increases in the academic achievements of students in the lowest socioeconomic background were most pronounced in mathematics and science as their scores improved 17 and 18 points, respectively, during that period while the middle class students showed no significant score changes. The conclusion that Korea's accountability policy had positive effect on achievements of poorest students is further reinforced by the results of 2012-2015 period. It can be seen that the positive improvement was reversed to significant decline in the 2012-2015 period such that although the decline was also true for the middle class students, the relative changes in both scores and probability of receiving level 1 proficiency during the period were significantly worse for the least wealthy students in comparison. Looking at the general pattern of results across the three periods especially involving introduction and removal of the policy present robust evidence consistent with the view that the school accountability policy had positive effect on reducing education inequality by family background.

A similar conclusion is reached for the subsample analyses involving low socioeconomic private schools as shown in Table 5. The findings show that when the school accountability

policy was introduced during the 2009-2012 period, the students from poor family background attending low socioeconomic private schools performed reasonably well to counter the declining academic performance that occurred the 2006-2009 period. More importantly, when the policy was removed during the 2012-2015 period, students from the poorest family background suffered the most in terms of academic development as their performance deteriorated at even greater level and were much more likely to be included in the level 1 proficiency group than the middle socioeconomic quintile students.

The overall pattern of results for private school students closely mirrors that of the low socioeconomic public school subsample, which means that for low socioeconomic schools the accountability policy worked similarly regardless of school types. The fact that the low socioeconomic schools responded so well in the predicted directions indicate that financial assistance–the key feature of Korea's school accountability policy–might have had instrument role by providing necessary resources to schools to instruct low achieving students, who largely come from poor family background and cannot afford private tutoring.

**Table 4. Difference-in-Difference Regressions from 2006 to 2015: Low Socioeconomic Schools by School Type**

| Public Low ESCS School | | | Mathematics (4) | Science (5) | Reading (6) |
|---|---|---|---|---|---|
| 2006-2009 Period *N* =2,738 | Score | Period | -1.866(16.978) | 21.979(14.443) | -1.467(12.965) |
| | | Bottom | -6.135(8.470) | -0.285(8.420) | 3.419(9.109) |
| | | Period x Bottom | -20.261(10.791)+ | -21.843(11.105)* | -25.634(10.606)* |
| | Level 1 | Period | -0.008(0.059) | -0.090(0.042)* | -0.052(0.045) |
| | | Bottom | 0.011(0.045) | -0.015(0.039) | -0.039(0.039) |
| | | Period x Bottom | 0.076(0.067) | 0.083(0.052) | 0.119(0.051)* |
| 2009-2012 Period *N* =2,894 | Score | Period | 4.07(16.066) | -4.561(14.596) | -16.449(13.458) |
| | | Bottom | -26.121(5.927)*** | -22.305(6.875)** | -22.91(5.599)*** |
| | | Period x Bottom | 17.352(9.35)+ | 18.173(9.817)+ | 14.433(10.461) |
| | Level 1 | Period | -0.018(0.056) | 0.002(0.041) | 0.058(0.048) |
| | | Bottom | 0.089(0.037)* | 0.072(0.032)* | 0.083(0.033)* |
| | | Period x Bottom | -0.056(0.049) | -0.056(0.05) | -0.052(0.059) |
| 2012-2015 Period *N* =3,332 | Score | Period | -14.47(12.853) | -13.347(11.465) | -10.557(12.01) |
| | | Bottom | -7.21(6.728) | -3.921(5.679) | -7.746(7.623) |
| | | Period x Bottom | -20.835(10.839)+ | -19.932(8.5)* | -17.407(9.988)+ |

| | | | | | |
|---|---|---|---|---|---|
| | Level 1 | Period | 0.077(0.041)+ | 0.087(0.037)* | 0.056(0.038) |
| | | Bottom | 0.027(0.03) | 0.015(0.028) | 0.03(0.034) |
| | | Period x Bottom | 0.081(0.047)+ | 0.076(0.043)+ | 0.052(0.05) |

| Private Low ESCS School | | | Mathematics (7) | Science (8) | Reading (9) |
|---|---|---|---|---|---|
| 2006-2009 Period *N* =2,253 | Score | Period | 17.149(18.616) | 39.332(17.704)* | 7.603(14.575) |
| | | Bottom | -0.823(9.342) | -0.043(8.880) | 2.935(7.150) |
| | | Period x Bottom | -30.933(13.670)* | -28.75(12.726)* | -28.591(11.224)* |
| | Level 1 | Period | -0.042(0.059) | -0.094(0.056)+ | 0.000(0.046) |
| | | Bottom | 0.029(0.035) | 0.019(0.034) | 0.014(0.029) |
| | | Period x Bottom | 0.021(0.051) | 0.019(0.043) | 0.004(0.040) |
| 2009-2012 Period *N* =1,989 | Score | Period | 0.099(21.833) | -2.052(19.761) | -10.405(17.962) |
| | | Bottom | -36.077(9.151)*** | -31.532(8.325)*** | -27.949(8.312)*** |
| | | Period x Bottom | 13.037(11.436) | 15.074(10.374) | 9.778(10.652) |
| | Level 1 | Period | 0.021(0.059) | -0.005(0.046) | 0.023(0.055) |
| | | Bottom | 0.058(0.035)+ | 0.045(0.027) | 0.024(0.031) |
| | | Period x Bottom | -0.033(0.052) | -0.050(0.046) | -0.001(0.051) |
| 2012-2015 Period *N* =1,886 | Score | Period | -19.872(15.927) | -19.453(15.168) | -12.29(15.752) |
| | | Bottom | -24.142(8.828)** | -17.092(7.287)* | -19.567(8.294)* |
| | | Period x Bottom | -28.628(13.387)* | -24.365(11.046)* | -17.988(13.478) |
| | Level 1 | Period | 0.043(0.058) | 0.074(0.053) | 0.083(0.056) |
| | | Bottom | 0.029(0.038) | -0.002(0.031) | 0.027(0.037) |
| | | Period x Bottom | 0.151(0.070)* | 0.127(0.047)** | 0.051(0.063) |

*Note*: All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method. Detailed table show n in Appendix B.

As shown in Table 5, results are quite different for the sample comprised of high socioeconomic status public school students. For this sample group, there was no pre-existing trend showing relative differences between students in the bottom and third quintile socioeconomic status in terms of changes in subject scores or probability of receiving level 1 proficiency in 2006-2009 period. This means that the students from the poorest family background were essentially performing at the same academic level as the middle class students until 2009. More importantly, the results showed that the changes in the mathematics and reading scores during the 2009-2012 period were significantly lower for the bottom quintile group when they were compared to those of third quintile group, which indicates that the students from the least favorable background suffered academically while the middle class students, albeit not

statistically significant, showed signs of academic improvements. This is rather unexpected finding and is in sharp contrast with the result of the low socioeconomic public school sample. Nevertheless, several speculations can be made for the observed discrepancy. First is the average academic performance of schools with high socioeconomic status. On average, students attending high socioeconomic status schools tend to perform better than those in the low socioeconomic status schools, which means that high socioeconomic schools are much less likely to be designated as the School for Improvement participant and receive financial and other assistances. On top of this, the pressure from accountability policy could have led to teachers to strategically focus on the borderline students who might be composed of students from the middle class background.

Finally, for the 2012-2015 period, no significant difference was observed for changes in scores between the bottom and third quintile group students, but for changes in the probability of receiving level 1 proficiency, there were significant differences such that the bottom quintile group students were much more likely to become level 1 proficient than the third quintile group students in 2015 compared to 2012. This means that although both student groups showed general decline in academic achievements when the accountability policy was removed, the students from low socioeconomic background were much closer to the borderline of becoming level 1 proficient than those from middle class students.

For the students attending high socioeconomic private schools, the results were less interesting. As shown in the lower half of Table 5, across analysis periods, the students from the poorest family background were consistently performing worse than the middle class students, suggesting that education inequality have existed persistently within high socioeconomic private schools. Nevertheless, the evidence also indicates that the pre-existing achievement gaps

between the two groups did not widen as a result of introducing or removing the accountability policy. All in all, the high socioeconomic private schools seemed to have been largely unaffected by the policy.

**Table 5. Difference-in-Difference Regressions from 2006 to 2015: High Socioeconomic Schools by School Type**

| Public High ESCS School | | | Mathematics (10) | Science (11) | Reading (12) |
|---|---|---|---|---|---|
| 2006-2009 Period $N$=2,946 | Score | Period | -8.533(14.566) | 1.181(14.032) | -26.267(11.876)* |
| | | Bottom | -8.446(8.585) | -9.633(9.026) | -3.234(8.335) |
| | | Period x Bottom | -5.634(11.798) | -0.477(12.212) | -8.329(11.255) |
| | Level 1 | Period | -0.017(0.022) | -0.022(0.022) | -0.004(0.018) |
| | | Bottom | 0.014(0.031) | 0.026(0.024) | -0.010(0.016) |
| | | Period x Bottom | 0.018(0.045) | -0.008(0.037) | 0.046(0.030) |
| 2009-2012 Period $N$=2,710 | Score | Period | 8.988(19.327) | 4.020(18.442) | 8.119(15.642) |
| | | Bottom | -13.786(8.531) | -10.759(8.151) | -11.716(8.163) |
| | | Period x Bottom | -28.973(14.287)* | -19.896(12.729) | -23.516(12.545)+ |
| | Level 1 | Period | 0.053(0.036) | 0.048(0.030) | 0.052(0.031)+ |
| | | Bottom | 0.031(0.029) | 0.017(0.026) | 0.036(0.027) |
| | | Period x Bottom | -0.005(0.045) | 0.002(0.044) | -0.018(0.049) |
| 2012-2015 Period $N$=2,924 | Score | Period | -27.070(14.830)+ | -23.734(12.453)+ | -18.333(13.061) |
| | | Bottom | -41.951(11.176)*** | -29.822(8.869)*** | -34.674(9.049)*** |
| | | Period x Bottom | -9.881(14.006) | -9.307(11.642) | -8.022(12.325) |
| | Level 1 | Period | -0.002(0.042) | 0.014(0.036) | 0.002(0.037) |
| | | Bottom | 0.022(0.033) | 0.018(0.028) | 0.018(0.034) |
| | | Period x Bottom | 0.094(0.052)+ | 0.096(0.045)* | 0.101(0.053)+ |

| Private High ESCS School | | | Mathematics (13) | Science (14) | Reading (15) |
|---|---|---|---|---|---|
| 2006-2009 Period $N$=1,995 | Score | Period | -13.88(16.111) | 2.468(14.179) | -35.149(13.702)* |
| | | Bottom | -19.546(9.664)* | -23.017(7.626)** | -14.334(8.779) |
| | | Period x Bottom | -3.846(13.420) | 1.606(12.408) | -5.429(13.152) |
| | Level 1 | Period | 0.006(0.019) | -0.013(0.018) | 0.001(0.014) |
| | | Bottom | 0.007(0.028) | 0.024(0.028) | 0.012(0.018) |
| | | Period x Bottom | 0.001(0.034) | 0.017(0.046) | 0.011(0.028) |
| 2009-2012 Period $N$=2,146 | Score | Period | 25.002(12.247)* | 2.976(10.744) | 10.187(11.491) |
| | | Bottom | -18.895(9.190)* | -17.21(9.362)+ | -16.863(9.296)+ |
| | | Period x Bottom | -8.506(15.676) | -3.435(13.430) | -9.937(13.577) |
| | Level 1 | Period | 0.006(0.018) | 0.014(0.016) | 0.025(0.017) |
| | | Bottom | 0.004(0.024) | 0.036(0.031) | 0.022(0.020) |
| | | Period x Bottom | 0.039(0.045) | -0.007(0.034) | 0.022(0.045) |
| 2012-2015 Period $N$=2,258 | Score | Period | -50.283(13.928)*** | -31.042(12.887)* | -26.875(13.847)+ |
| | | Bottom | -28.626(11.98)* | -21.548(9.393)* | -28.084(10.660)** |
| | | Period x Bottom | 2.069(16.637) | 1.741(15.973) | 14.803(16.809) |
| | Level 1 | Period | 0.069(0.029)* | 0.069(0.031)* | 0.056(0.031)+ |
| | | Bottom | 0.042(0.033) | 0.028(0.022) | 0.043(0.042) |
| | | Period x Bottom | -0.018(0.053) | -0.024(0.042) | -0.041(0.054) |

*Note*: All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method. Detailed table shown in Appendix C.

## 5. Robustness Check: Difference-in-Difference Analyses for Policy Effect on School Performances

In the previous section, the effect of school accountability policy on performance of students in low socioeconomic status were explored. Although the beneficiaries of the accountability policy were academically under-achieving students and those from poor family backgrounds, the specific targets of the policy in Korea were underperforming schools as defined by high proportion of low achieving students in the NAEA.[11] This means that if the accountability policy had the intended positive effects, the overall gains in average scores should be higher for previously underperforming schools during the period when the policy was in place. Conversely, performances for underperforming schools should be much worse in the period when the accountability policy was gradually weakened. These predictions can be confirmed with school-level PISA data. Therefore, additional difference-in-difference analyses at the school-level were performed as robustness checks of the previous individual-level analyses. The common model used is shown in the Equation 2.

$$y_{st} = \beta_0 + \beta_1 Period_t + \beta_2 Bottom_s + \beta_3 (Period_t * Bottom_s)_{st} + S_{st}\gamma + \epsilon \qquad (2)$$

In this equation, $y_{st}$ is mean PISA test scores of each subject (science, mathematics, and reading) for each school $s$ in time $t$. $Period_t$ is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2015 for the 2012-2015 analysis. $Bottom_s$ is a dummy variable indicating whether each school $s$ belongs to bottom quintile group in terms of schools' average ESCS level and is compared to all other

[11] The cut-off for being designated as underperforming schools was 20%.

groups. As for the $(Period*Bottom)_{st}$ variable, it is an interaction term of aforementioned variables. Finally, $S_{st}$ is a vector of school-level controls.[12] Analyses using this model were repeated with schools' proportion of level 1 proficiency students in each subject as the dependent variable.

The key results of analyses are summarized in Table 6. Firstly, the results of changes in the performance of schools around the periods before the introduction of the accountability policies (2006-2009 period) suggest some evidence of declining academic performance of bottom socioeconomic quintile schools. Although the average subject scores were non-significantly different from those of higher socioeconomic schools, the proportion of level 1 proficiency students increased much more in the bottom quintile group than in the higher socioeconomic schools. Conversely, in the 2009-2012 period when the accountability policy was implemented, improvements in scores as well as proportion of level 1 proficiency students across all subject areas were significantly greater for the bottom socioeconomic quintile schools than for higher socioeconomic quintile schools with the onset of the accountability policy. This in effect reversed the relative downward trend of lowest socioeconomic schools as observed in the 2006-2009 period. Finally, in the 2012-2015 period when the accountability policy was gradually weakened, changes in the average subject scores for the bottom quintile schools did not show significant differences to all the other schools. Nevertheless, the results indicated that the changes in the proportion of level 1 proficiency students in science and reading were significantly higher in the lowest quintile schools than other schools. As a whole, the results of the school-level analyses are largely in line with the expectations in that the bottom

[12] For school-level controls, private school dummy, school size, female student ratio, student to teacher ratio, location of school (each dummy variable indicating town, city, and large city; reference group is village/small town), and short of teaching materials (each dummy variable indicating none at all and a lot with very little/to some extent being the reference group).

socioeconomic schools generally experienced positive gains during the period when the accountability policy was in place, but the gain disappeared when the support for the policy was drastically reduced.

As for the differences in the policy effects between public and private schools, a summary of the results in Table 6 shows that changes in average subject scores of the bottom socioeconomic public schools from 2006 to 2009 were not significantly different to other public schools. On the other hand, the changes in the scores for the lowest quintile private schools were significantly more negative compared to other private schools such that their changed scores were 32 to 60 points lower than those from other private schools. Furthermore, as expectedly, changes in the subject scores from 2009 to 2012 were significantly positive and greater for the public schools in the bottom quintile than those for the all other public schools. Conversely, no such differences were observed for the bottom quintile private schools compared to other private schools. This is a suggestive evidence that the lowest quintile schools especially in the public sector was more strongly responsive to the accountability policy.

Finally, consistent with the prediction, from 2012 to 2015, the changes in all subject scores were significantly more negative for the bottom quintile public schools than other public schools such that the bottom schools were 32 to 48 points lower than other public schools across the three PISA subjects. In contrast, among private schools, the differences in averaged scores across the same period tended to not differ significantly between lowest socioeconomic schools and other schools. As a whole, the results of difference-in-differences analyses were highly consistent with the predictions that public schools would be affected highly by the accountability policy while the effects on the private schools would be more muted.

All in all, the results in Table 6 collaborate with those of individual-level analyses to suggest that the accountability and support policies as well as removal of the NAEA for elementary school students and general lack of willingness to support underperforming schools (e.g., withdrawal of financial supports to schools identified as failing) were significant contributors to the academic achievement of students, particularly for those attending public schools.

**Table 6. Difference-in-Difference Regressions of Schools in Korea from 2006 to 2015**

| Overall | | Scores | | | Level 1 Proficiency | | |
|---|---|---|---|---|---|---|---|
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2006-2009 Period | (Period x Bottom) | -29.96 | -18.66 | -21.73 | 0.0908+ | 0.0530 | 0.100+ |
| | | (18.73) | (17.54) | (16.68) | (0.0544) | (0.0567) | (0.0518) |
| 2009-2012 Period | (Period x Bottom) | 46.04* | 40.86* | 47.32* | -0.138* | -0.131* | -0.142* |
| | | (23.37) | (19.88) | (20.92) | (0.0585) | (0.0597) | (0.0592) |
| 2012-2015 Period | (Period x Bottom) | -7.87 | -9.94 | -16.36 | 0.0923+ | 0.0706 | 0.0795+ |
| | | (17.27) | (14.26) | (15.72) | (0.0500) | (0.0445) | (0.0457) |

| Public Schools | | Scores | | | Level 1 Proficiency | | |
|---|---|---|---|---|---|---|---|
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2006-2009 Period | (Period x Bottom) | -19.81 | -13.56 | -10.95 | 0.0866 | 0.0578 | 0.0849 |
| | | (23.84) | (21.25) | (19.12) | (0.0727) | (0.0763) | (0.0729) |
| 2009-2012 Period | (Period x Bottom) | 76.86** | 70.73*** | 76.20** | -0.233*** | -0.231** | -0.220** |
| | | (23.23) | (19.95) | (25.39) | (0.0637) | (0.0698) | (0.0712) |
| 2012-2015 Period | (Period x Bottom) | -32.45* | -32.83* | -47.74** | 0.161*** | 0.131** | 0.137** |
| | | (15.38) | (13.15) | (16.37) | (0.0467) | (0.0446) | (0.0481) |

| Private Schools | | Scores | | | Level 1 Proficiency | | |
|---|---|---|---|---|---|---|---|
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2006-2009 Period | (Period x Bottom) | -57.24** | -30.45 | -40.25+ | 0.113+ | 0.0181 | 0.110+ |
| | | (21.33) | (18.80) | (20.43) | (0.0589) | (0.0624) | (0.0587) |
| 2009-2012 Period | (Period x Bottom) | 22.81 | 14.23 | 29.04 | -0.0565 | -0.0101 | -0.0643 |
| | | (24.40) | (19.21) | (18.98) | (0.0500) | (0.0378) | (0.0657) |
| 2012-2015 Period | (Period x Bottom) | 9.432 | 3.517 | 14.33 | 0.0387 | -0.00211 | -0.0116 |
| | | (34.52) | (28.02) | (26.38) | (0.112) | (0.0972) | (0.0869) |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom dummy variable indicates schools belonging to the bottom quintile in terms of the average ESCS level of schools. Finally, (Period*Bottom) variable is an interaction of aforementioned variables. All analyses include for school-level controls. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate robust standard errors. Detailed table shown in Appendix C.

## 6. Conclusions

The impact of Korea's accountability policy on academic performance of students and schools with low socioeconomic status were examined in this paper. Overall, the evidence gathered in this paper indicates that active implementation of the NAEA and School for Improvement policy (2009-2012 period) were effective in raising the academic performance of students and schools in the lowest socioeconomic strata. However, when the school accountability policies were gradually abolished (2012-2015), education achievements of students from poor family background as well as the overall performance of low achieving public schools worsened significantly. Most importantly, the striking fact is that it was only public schools that experienced gains and exacerbations in school performance in accordance with the status of accountability policy. Conversely, private schools somewhat gained from the implementation of the policy and resisted negative consequences following the gradual abolishment of the policy.

There needs to be deep reflections as to why school accountability policy was not able to take root and be abolished in Korea despite the fact that it improved academic achievement of students from poor family background (e.g., Cha & Min, 2013; Woo, Lee, & Kim, 2015) and that removal of the policy led to deterioration of their academic achievements.

Although the NAEA for elementary school was abolished in 2013 because it was not consistent with the governing direction of educational policies of promoting dreams and talents, abolishing the test, which just started to take root in the field and was initiated to help low performing students, was understood by schools and education offices that the will of the central government to raise achievements of underperforming students has faded, impeding further efforts of teacher in the field to help low performing students. The problem may lie in dichotomous thinking in education that emphasis on education achievement conflicts with promotion of creativity and good character. Rather, the strategy required here is dual focus

approach, as pointed out by Elias (2009), that focuses on cognitive capacity (academic achievement) and also at the same time on non-cognitive capacities such as creativity and good character, which of course will require further rigorous studies.

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# Appendix A

## Table A1. Difference-in-Difference Regressions from 2006 to 2015 (Score)

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | 4.015(9.084) | 22.919(8.182)** | -6.517(7.57) |
| | Bottom | -11.029(4.775)* | -9.699(4.616)* | -5.178(4.255) |
| | 2nd Quintile | -4.918(3.67) | -6.399(3.875)+ | -3.03(3.624) |
| | 4th Quintile | 8.32(4.463)+ | 7.272(4.42)+ | 7.023(4.391) |
| | Top | 33.236(6.098)*** | 28.301(5.419)*** | 27.575(5.19)*** |
| | (Period*Bottom) | -14.715(6.695)* | -12.58(6.784)+ | -14.987(5.791)** |
| | (Period*2nd Quintile) | -7.108(5.604) | -1.843(5.632) | -6.006(5.25) |
| | (Period*4th Quintile) | -2.487(6.121) | -0.616(6.076) | -2.226(5.439) |
| | (Period*Top) | -9.163(9.289) | -9.546(8.413) | -9.463(6.995) |
| | Constant | 140.244(60.493)* | 100.773(61.083)+ | 200.885(61.349)** |
| | $R^2$ | 0.202 | 0.176 | 0.220 |
| | Observations | 9932 | 9932 | 9932 |
| 2009-2012 Period | Period | 11.151(9.041) | 0.833(7.619) | -1.728(7.272) |
| | Bottom | -26.932(4.335)*** | -24.87(4.366)*** | -22.031(3.884)*** |
| | 2nd Quintile | -12.285(4.334)** | -9.176(3.672)* | -9.345(3.5)** |
| | 4th Quintile | 6.434(3.872)+ | 7.384(4.18)+ | 5.291(3.522) |
| | Top | 24.973(5.608)*** | 20.325(5.383)*** | 19.172(4.32)*** |
| | (Period*Bottom) | 1.115(6.601) | 7.856(5.944) | -0.193(6.172) |
| | (Period*2nd Quintile) | -1.888(6.274) | -2.439(5.202) | -2.765(5.099) |
| | (Period*4th Quintile) | 1.915(5.101) | -4.762(4.99) | 0.419(4.691) |
| | (Period*Top) | 4.918(7.524) | -2.129(6.452) | 2.902(5.853) |
| | Constant | 1.115(6.601) | 7.856(5.944) | -0.193(6.172) |
| | $R^2$ | 0.193 | 0.152 | 0.193 |
| | Observations | 9739 | 9739 | 9739 |
| 2012-2015 Period | Period | -26.73(6.952)*** | -21.252(6.122)*** | -17.003(6.726)* |
| | Bottom | -26.681(4.825)*** | -17.462(3.751)*** | -22.438(4.786)*** |
| | 2nd Quintile | -14.441(4.163)*** | -11.46(3.679)** | -11.948(3.909)** |
| | 4th Quintile | 8.802(4.392)* | 2.835(3.538) | 5.674(4.059) |
| | Top | 30.43(4.241)*** | 18.011(3.668)*** | 21.36(3.814)*** |
| | (Period*Bottom) | -9.335(6.632) | -11.4(5.312)* | -5.606(6.775) |
| | (Period*2nd Quintile) | 0.231(5.217) | 0.168(4.972) | 0.23(5.312) |
| | (Period*4th Quintile) | 3.289(6.066) | 8.491(5.373) | 4.644(5.883) |
| | (Period*Top) | 6.957(6.274) | 14.389(5.192)** | 7.701(5.331) |
| | Constant | 352.28(61.188)*** | 342.694(46.536)*** | 364.904(46.413)*** |
| | $R^2$ | 0.198 | 0.160 | 0.185 |
| | Observations | 10400 | 10400 | 10400 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

## Table A2. Difference-in-Difference Regressions from 2006 to 2015 (Level 1 Proficiency)

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | -0.019(0.025) | -0.065(0.017)*** | -0.024(0.018) |
| | Bottom | 0.025(0.019) | 0.025(0.018) | -0.001(0.017) |
| | 2nd Quintile | -0.001(0.014) | 0.015(0.015) | 0(0.012) |
| | 4th Quintile | -0.009(0.014) | -0.015(0.015) | -0.005(0.014) |
| | Top | -0.037(0.013)** | -0.039(0.013)** | -0.024(0.011)* |
| | (Period*Bottom) | 0.038(0.031) | 0.023(0.027) | 0.057(0.024)* |
| | (Period*2nd Quintile) | 0.024(0.02) | -0.001(0.018) | 0.009(0.016) |
| | (Period*4th Quintile) | 0.004(0.021) | 0.007(0.019) | 0.006(0.017) |
| | (Period*Top) | 0.032(0.02) | 0.037(0.018)* | 0.024(0.014)+ |
| | Constant | 0.906(0.265)*** | 0.934(0.248)*** | 0.495(0.299)+ |
| | $R^2$ | 0.080 | 0.073 | 0.077 |
| | Observations | 9932 | 9932 | 9932 |
| 2009-2012 Period | Period | 0.007(0.024) | 0.009(0.017) | 0.033(0.021) |
| | Bottom | 0.068(0.02)*** | 0.059(0.019)** | 0.058(0.018)** |
| | 2nd Quintile | 0.024(0.017) | 0.018(0.014) | 0.009(0.012) |
| | 4th Quintile | -0.007(0.013) | -0.012(0.011) | 0(0.011) |
| | Top | -0.007(0.012) | -0.009(0.011) | -0.001(0.009) |
| | (Period*Bottom) | -0.037(0.029) | -0.049(0.027)+ | -0.027(0.032) |
| | (Period*2nd Quintile) | -0.018(0.026) | -0.017(0.02) | -0.013(0.022) |
| | (Period*4th Quintile) | 0.002(0.019) | 0.012(0.015) | -0.006(0.015) |
| | (Period*Top) | -0.014(0.02) | -0.003(0.015) | -0.02(0.014) |
| | Constant | -0.037(0.029) | -0.049(0.027)+ | -0.027(0.032) |
| | $R^2$ | 0.069 | 0.054 | 0.068 |
| | Observations | 9739 | 9739 | 9739 |
| 2012-2015 Period | Period | 0.044(0.018)* | 0.06(0.018)*** | 0.047(0.018)* |
| | Bottom | 0.031(0.017)+ | 0.009(0.014) | 0.031(0.019) |
| | 2nd Quintile | 0.005(0.015) | 0(0.012) | -0.004(0.015) |
| | 4th Quintile | -0.006(0.014) | 0(0.012) | -0.005(0.012) |
| | Top | -0.02(0.013) | -0.009(0.011) | -0.018(0.01)+ |
| | (Period*Bottom) | 0.088(0.028)** | 0.088(0.024)*** | 0.052(0.029)+ |
| | (Period*2nd Quintile) | 0.028(0.023) | 0.029(0.02) | 0.027(0.022) |
| | (Period*4th Quintile) | -0.024(0.021) | -0.028(0.019) | -0.025(0.02) |
| | (Period*Top) | -0.031(0.019)+ | -0.034(0.017)* | -0.024(0.017) |
| | Constant | 0.572(0.206)** | 0.541(0.208)** | 0.503(0.192)** |
| | $R^2$ | 0.072 | 0.067 | 0.072 |
| | Observations | 10400 | 10400 | 10400 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

# Appendix B

## Table B1. Difference-in-Difference Regressions from 2006 to 2015: Low Socioeconomic Public School (Score)

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | -1.866(16.978) | 21.979(14.443) | -1.467(12.965) |
| | Bottom | -6.135(8.47) | -0.285(8.42) | 3.419(9.109) |
| | 2nd Quintile | -8.951(6.26) | -6.391(5.468) | -4.171(6.662) |
| | 4th Quintile | 11.048(9.269) | 14.102(9.03) | 11.733(9.243) |
| | Top | 33.749(8.847)*** | 36.007(8.326)*** | 37.114(8.924)*** |
| | (Period*Bottom) | -20.261(10.791)+ | -21.843(11.105)* | -25.634(10.606)* |
| | (Period*2nd Quintile) | -4.488(9.87) | -2.358(9.401) | -7.139(9.182) |
| | (Period*4th Quintile) | -6.362(10.086) | -6.745(10.908) | -8.777(10.077) |
| | (Period*Top) | -20.122(13.089) | -22.261(12.694)+ | -29.093(11.062)** |
| | Constant | 311.434(121.615)* | 252.449(144.388)+ | 368.018(123.499)** |
| | $R^2$ | 0.138 | 0.126 | 0.166 |
| | Observations | 2738 | 2738 | 2738 |
| 2009-2012 Period | Period | 4.07(16.066) | -4.561(14.596) | -16.449(13.458) |
| | Bottom | -26.121(5.927)*** | -22.305(6.875)** | -22.91(5.599)*** |
| | 2nd Quintile | -13.496(7.543)+ | -8.611(7.718) | -11.067(6.727)+ |
| | 4th Quintile | 4.124(7.274) | 7.136(7.596) | 2.952(6.832) |
| | Top | 13.123(9.534) | 14.281(10.498) | 8.606(8.389) |
| | (Period*Bottom) | 17.352(9.35)+ | 18.173(9.817)+ | 14.433(10.461) |
| | (Period*2nd Quintile) | 5.225(10.537) | 0.247(9.586) | 2.439(8.93) |
| | (Period*4th Quintile) | -10.266(10.731) | -17.687(9.712)+ | -8.613(9.776) |
| | (Period*Top) | -4.605(13.101) | -15.358(12.076) | -5.906(12.165) |
| | Constant | 17.352(9.35)+ | 18.173(9.817)+ | 14.433(10.461) |
| | $R^2$ | 0.148 | 0.127 | 0.185 |
| | Observations | 2894 | 2894 | 2894 |
| 2012-2015 Period | Period | -14.47(12.853) | -13.347(11.465) | -10.557(12.01) |
| | Bottom | -7.21(6.728) | -3.921(5.679) | -7.746(7.623) |
| | 2nd Quintile | -7.077(6.221) | -6.934(5.403) | -6.422(5.872) |
| | 4th Quintile | -7.116(9.33) | -11.252(7.81) | -6.073(8.914) |
| | Top | 9.074(8.258) | 0.131(7.764) | 3.41(8.427) |
| | (Period*Bottom) | -20.835(10.839)+ | -19.932(8.5)* | -17.407(9.988)+ |
| | (Period*2nd Quintile) | -4.936(8.996) | -3.65(7.204) | -4.442(8.234) |
| | (Period*4th Quintile) | 24.393(12.384)* | 20.501(10.863)+ | 15.723(12.124) |
| | (Period*Top) | 33.755(12.153)** | 34.28(10.449)** | 31.117(11.508)** |
| | Constant | 298.786(91.282)** | 341.405(88.383)*** | 279.163(93.589)** |
| | $R^2$ | 0.135 | 0.108 | 0.153 |
| | Observations | 3332 | 3332 | 3332 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

**Table B2. Difference-in-Difference Regressions from 2006 to 2015: Low Socioeconomic Public School (Level 1 Proficiency)**

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | -0.008(0.059) | -0.09(0.042)* | -0.052(0.045) |
| | Bottom | 0.011(0.045) | -0.015(0.039) | -0.039(0.039) |
| | 2nd Quintile | 0.006(0.029) | 0.018(0.03) | -0.016(0.027) |
| | 4th Quintile | -0.027(0.044) | -0.05(0.047) | -0.025(0.036) |
| | Top | -0.066(0.035)+ | -0.081(0.041)* | -0.077(0.031)* |
| | (Period*Bottom) | 0.076(0.067) | 0.083(0.052) | 0.119(0.051)* |
| | (Period*2nd Quintile) | 0.026(0.05) | 0.008(0.041) | 0.031(0.041) |
| | (Period*4th Quintile) | 0.014(0.054) | 0.034(0.048) | 0.028(0.048) |
| | (Period*Top) | 0.077(0.047) | 0.078(0.05) | 0.098(0.039)* |
| | Constant | 0.68(0.545) | 0.938(0.635) | 0.064(0.599) |
| | $R^2$ | 0.071 | 0.066 | 0.094 |
| | Observations | 2738 | 2738 | 2738 |
| 2009-2012 Period | Period | -0.018(0.056) | 0.002(0.041) | 0.058(0.048) |
| | Bottom | 0.089(0.037)* | 0.072(0.032)* | 0.083(0.033)* |
| | 2nd Quintile | 0.032(0.039) | 0.025(0.03) | 0.014(0.03) |
| | 4th Quintile | -0.012(0.037) | -0.017(0.03) | 0.002(0.032) |
| | Top | 0.01(0.036) | -0.005(0.038) | 0.02(0.028) |
| | (Period*Bottom) | -0.056(0.049) | -0.056(0.05) | -0.052(0.059) |
| | (Period*2nd Quintile) | 0.014(0.05) | 0.012(0.044) | 0.001(0.039) |
| | (Period*4th Quintile) | 0.076(0.049) | 0.071(0.042)+ | 0.036(0.047) |
| | (Period*Top) | 0.008(0.052) | 0.035(0.05) | -0.007(0.041) |
| | Constant | -0.056(0.049) | -0.056(0.05) | -0.052(0.059) |
| | $R^2$ | 0.075 | 0.068 | 0.093 |
| | Observations | 2894 | 2894 | 2894 |
| 2012-2015 Period | Period | 0.077(0.041)+ | 0.087(0.037)* | 0.056(0.038) |
| | Bottom | 0.027(0.03) | 0.015(0.028) | 0.03(0.034) |
| | 2nd Quintile | 0.041(0.028) | 0.032(0.025) | 0.009(0.029) |
| | 4th Quintile | 0.064(0.035)+ | 0.053(0.026)* | 0.036(0.035) |
| | Top | 0.017(0.031) | 0.024(0.028) | 0.006(0.031) |
| | (Period*Bottom) | 0.081(0.047)+ | 0.076(0.043)+ | 0.052(0.05) |
| | (Period*2nd Quintile) | -0.004(0.044) | 0.005(0.036) | 0.02(0.042) |
| | (Period*4th Quintile) | -0.099(0.051)* | -0.072(0.042)+ | -0.056(0.051) |
| | (Period*Top) | -0.114(0.049)* | -0.118(0.039)** | -0.085(0.044)+ |
| | Constant | 0.898(0.488)+ | 0.788(0.534) | 0.857(0.444)+ |
| | $R^2$ | 0.064 | 0.059 | 0.070 |
| | Observations | 3332 | 3332 | 3332 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

## Table B3. Difference-in-Difference Regressions from 2006 to 2015: Low Socioeconomic Private School (Score)

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | 17.149(18.616) | 39.332(17.704)* | 7.603(14.575) |
| | Bottom | -0.823(9.342) | -0.043(8.88) | 2.935(7.15) |
| | 2nd Quintile | -0.618(7.707) | -0.005(8.395) | 2.227(7.698) |
| | 4th Quintile | 7.241(8.559) | 7.751(9.012) | 6.368(7.78) |
| | Top | 24.448(9.399)** | 19.628(8.991)* | 18.228(7.719)* |
| | (Period*Bottom) | -30.933(13.67)* | -28.75(12.726)* | -28.591(11.224)* |
| | (Period*2nd Quintile) | -26.101(11.758)* | -19.351(11.569)+ | -24.025(11.376)* |
| | (Period*4th Quintile) | -5.587(13.381) | -5.651(14.096) | -7.415(12.402) |
| | (Period*Top) | -0.362(16.763) | -2.643(15.768) | -0.158(14.631) |
| | Constant | 15.831(115.13) | -46.896(127.838) | 25.198(114.178) |
| | $R^2$ | 0.117 | 0.126 | 0.139 |
| | Observations | 2253 | 2253 | 2253 |
| 2009-2012 Period | Period | 0.099(21.833) | -2.052(19.761) | -10.405(17.962) |
| | Bottom | -36.077(9.151)*** | -31.532(8.325)*** | -27.949(8.312)*** |
| | 2nd Quintile | -28.501(8.63)*** | -20.176(7.077)** | -21.89(7.571)** |
| | 4th Quintile | -1.261(12.262) | 0.266(12.034) | -3.032(10.805) |
| | Top | 22.209(13.364)+ | 16.03(13.436) | 17.57(13.351) |
| | (Period*Bottom) | 13.037(11.436) | 15.074(10.374) | 9.778(10.652) |
| | (Period*2nd Quintile) | 19.522(11.23)+ | 10.893(9.244) | 15.792(9.991) |
| | (Period*4th Quintile) | 16.19(16.187) | 7.379(15.35) | 11.383(14.735) |
| | (Period*Top) | 10.784(14.488) | -0.683(12.849) | 6.032(12.964) |
| | Constant | 13.037(11.436) | 15.074(10.374) | 9.778(10.652) |
| | $R^2$ | 0.089 | 0.083 | 0.081 |
| | Observations | 1989 | 1989 | 1989 |
| 2012-2015 Period | Period | -19.872(15.927) | -19.453(15.168) | -12.29(15.752) |
| | Bottom | -24.142(8.828)** | -17.092(7.287)* | -19.567(8.294)* |
| | 2nd Quintile | -8.588(9.059) | -8.876(6.979) | -6.823(7.459) |
| | 4th Quintile | 16.008(10.965) | 8.118(9.261) | 8.317(9.77) |
| | Top | 30.636(8.363)*** | 13.727(8.167)+ | 21.797(6.892)** |
| | (Period*Bottom) | -28.628(13.387)* | -24.365(11.046)* | -17.988(13.478) |
| | (Period*2nd Quintile) | -22.037(14.775) | -19.22(13.77) | -21.062(14.394) |
| | (Period*4th Quintile) | -10.778(16.251) | -6.587(13.497) | -5.551(15.231) |
| | (Period*Top) | -12.319(20.344) | 0.09(18.335) | -9.512(18.081) |
| | Constant | 394.306(133.133)** | 412.727(123.575)*** | 425.794(141.438)** |
| | $R^2$ | 0.115 | 0.103 | 0.100 |
| | Observations | 1886 | 1886 | 1886 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

**Table B4. Difference-in-Difference Regressions from 2006 to 2015: Low Socioeconomic Private School (Level 1 Proficiency)**

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | -0.042(0.059) | -0.094(0.056)+ | 0(0.046) |
| | Bottom | 0.029(0.035) | 0.019(0.034) | 0.014(0.029) |
| | 2nd Quintile | -0.009(0.03) | -0.009(0.029) | 0.015(0.026) |
| | 4th Quintile | 0.004(0.041) | -0.016(0.034) | 0.01(0.035) |
| | Top | -0.063(0.039) | -0.037(0.035) | -0.014(0.027) |
| | (Period*Bottom) | 0.021(0.051) | 0.019(0.043) | 0.004(0.04) |
| | (Period*2nd Quintile) | 0.053(0.037) | 0.034(0.038) | -0.014(0.036) |
| | (Period*4th Quintile) | 0.005(0.053) | 0.015(0.047) | -0.016(0.05) |
| | (Period*Top) | 0.067(0.055) | 0.056(0.055) | 0.027(0.038) |
| | Constant | 1.824(0.582)** | 1.846(0.693)** | 1.243(0.648)+ |
| | $R^2$ | 0.047 | 0.056 | 0.061 |
| | Observations | 2253 | 2253 | 2253 |
| 2009-2012 Period | Period | 0.021(0.059) | -0.005(0.046) | 0.023(0.055) |
| | Bottom | 0.058(0.035)+ | 0.045(0.027) | 0.024(0.031) |
| | 2nd Quintile | 0.046(0.033) | 0.027(0.029) | 0.001(0.025) |
| | 4th Quintile | 0.012(0.033) | 0.002(0.033) | -0.002(0.034) |
| | Top | 0.008(0.042) | 0.022(0.04) | 0.013(0.032) |
| | (Period*Bottom) | -0.033(0.052) | -0.05(0.046) | -0.001(0.051) |
| | (Period*2nd Quintile) | -0.064(0.054) | -0.048(0.037) | -0.02(0.035) |
| | (Period*4th Quintile) | -0.033(0.054) | -0.009(0.047) | -0.007(0.042) |
| | (Period*Top) | -0.068(0.06) | -0.036(0.056) | -0.038(0.045) |
| | Constant | -0.033(0.052) | -0.05(0.046) | -0.001(0.051) |
| | $R^2$ | 0.027 | 0.029 | 0.033 |
| | Observations | 1989 | 1989 | 1989 |
| 2012-2015 Period | Period | 0.043(0.058) | 0.074(0.053) | 0.083(0.056) |
| | Bottom | 0.029(0.038) | -0.002(0.031) | 0.027(0.037) |
| | 2nd Quintile | -0.014(0.038) | -0.019(0.024) | -0.012(0.024) |
| | 4th Quintile | -0.018(0.043) | -0.006(0.032) | -0.007(0.034) |
| | Top | -0.049(0.035) | -0.007(0.04) | -0.018(0.033) |
| | (Period*Bottom) | 0.151(0.07)* | 0.127(0.047)** | 0.051(0.063) |
| | (Period*2nd Quintile) | 0.109(0.07) | 0.096(0.059) | 0.059(0.064) |
| | (Period*4th Quintile) | 0.021(0.071) | -0.013(0.054) | -0.026(0.056) |
| | (Period*Top) | 0.037(0.074) | 0.013(0.064) | -0.008(0.064) |
| | Constant | 0.527(0.669) | 0.323(0.654) | 0.544(0.611) |
| | $R^2$ | 0.061 | 0.070 | 0.066 |
| | Observations | 1886 | 1886 | 1886 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

# Appendix C

## Table C1. Difference-in-Difference Regressions from 2006 to 2015: High Socioeconomic Public School (Score)

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | -8.533(14.566) | 1.181(14.032) | -26.267(11.876)* |
| | Bottom | -8.446(8.585) | -9.633(9.026) | -3.234(8.335) |
| | 2nd Quintile | 1.301(6.793) | -3.295(7.796) | 3.46(6.972) |
| | 4th Quintile | -1.437(7.264) | -4.607(6.564) | -3.171(6.287) |
| | Top | 22.025(7.708)** | 17.319(7.453)* | 18.046(7.134)* |
| | (Period*Bottom) | -5.634(11.798) | -0.477(12.212) | -8.329(11.255) |
| | (Period*2nd Quintile) | 4.075(8.983) | 7.894(9.601) | 1.768(8.836) |
| | (Period*4th Quintile) | 22.366(10.498)* | 23.487(8.791)** | 20.785(8.554)* |
| | (Period*Top) | 7.724(9.874) | 7.892(10.431) | 8.204(9.354) |
| | Constant | 376.103(104.818)*** | 235.413(85.73)** | 427.964(84.857)*** |
| | $R^2$ | 0.142 | 0.106 | 0.151 |
| | Observations | 2946 | 2946 | 2946 |
| 2009-2012 Period | Period | 8.988(19.327) | 4.02(18.442) | 8.119(15.642) |
| | Bottom | -13.786(8.531) | -10.759(8.151) | -11.716(8.163) |
| | 2nd Quintile | 4.559(6.638) | 3.665(6.143) | 4.691(6.018) |
| | 4th Quintile | 21.649(6.488)*** | 18.849(5.967)** | 17.244(5.131)*** |
| | Top | 31.999(6.488)*** | 26.258(6.644)*** | 26.832(4.97)*** |
| | (Period*Bottom) | -28.973(14.287)* | -19.896(12.729) | -23.516(12.545)+ |
| | (Period*2nd Quintile) | -18.654(12.64) | -13.62(10.882) | -15.717(11.177) |
| | (Period*4th Quintile) | -2.296(10.217) | -9.302(8.428) | -6.551(8.754) |
| | (Period*Top) | -6.616(11.705) | -8.03(10.445) | -10.682(9.979) |
| | Constant | -28.973(14.287)* | -19.896(12.729) | -23.516(12.545)+ |
| | $R^2$ | 0.149 | 0.117 | 0.114 |
| | Observations | 2710 | 2710 | 2710 |
| 2012-2015 Period | Period | -27.07(14.83)+ | -23.734(12.453)+ | -18.333(13.061) |
| | Bottom | -41.951(11.176)*** | -29.822(8.869)*** | -34.674(9.049)*** |
| | 2nd Quintile | -14.107(10.48) | -10.492(8.565) | -11.9(8.603) |
| | 4th Quintile | 17.077(8.479)* | 7.317(6.325) | 9.119(6.87) |
| | Top | 25.441(9.688)** | 18.557(8.773)* | 15.862(8.557)+ |
| | (Period*Bottom) | -9.881(14.006) | -9.307(11.642) | -8.022(12.325) |
| | (Period*2nd Quintile) | -3.17(12.705) | -1.544(10.937) | -0.487(11.99) |
| | (Period*4th Quintile) | -15.737(11.339) | -0.583(9.818) | -3.812(10.362) |
| | (Period*Top) | 3.684(11.764) | 6.574(10.435) | 4.839(10.531) |
| | Constant | 362.803(113.078)** | 334.76(81.208)*** | 416.756(83.026)*** |
| | $R^2$ | 0.113 | 0.090 | 0.107 |
| | Observations | 2924 | 2924 | 2924 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

**Table C2. Difference-in-Difference Regressions from 2006 to 2015: High Socioeconomic Public School (Level 1 Proficiency)**

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | -0.017(0.022) | -0.022(0.022) | -0.004(0.018) |
| | Bottom | 0.014(0.031) | 0.026(0.024) | -0.01(0.016) |
| | 2nd Quintile | -0.01(0.02) | 0.021(0.028) | 0(0.017) |
| | 4th Quintile | -0.005(0.016) | 0.014(0.022) | 0.003(0.017) |
| | Top | -0.02(0.017) | -0.002(0.019) | -0.011(0.015) |
| | (Period*Bottom) | 0.018(0.045) | -0.008(0.037) | 0.046(0.03) |
| | (Period*2nd Quintile) | 0.017(0.026) | -0.022(0.034) | 0.008(0.024) |
| | (Period*4th Quintile) | -0.004(0.021) | -0.031(0.027) | -0.014(0.025) |
| | (Period*Top) | 0.006(0.019) | -0.016(0.022) | -0.003(0.018) |
| | Constant | 0.207(0.219) | 0.131(0.22) | -0.123(0.212) |
| | $R^2$ | 0.059 | 0.053 | 0.070 |
| | Observations | 2946 | 2946 | 2946 |
| 2009-2012 Period | Period | 0.053(0.036) | 0.048(0.03) | 0.052(0.031)+ |
| | Bottom | 0.031(0.029) | 0.017(0.026) | 0.036(0.027) |
| | 2nd Quintile | 0.008(0.018) | 0(0.018) | 0.009(0.018) |
| | 4th Quintile | -0.008(0.013) | -0.015(0.013) | -0.009(0.018) |
| | Top | -0.015(0.013) | -0.018(0.012) | -0.013(0.014) |
| | (Period*Bottom) | -0.005(0.045) | 0.002(0.044) | -0.018(0.049) |
| | (Period*2nd Quintile) | -0.049(0.04) | -0.05(0.039) | -0.052(0.035) |
| | (Period*4th Quintile) | -0.039(0.029) | -0.025(0.032) | -0.025(0.03) |
| | (Period*Top) | -0.027(0.034) | -0.017(0.029) | -0.018(0.026) |
| | Constant | -0.005(0.045) | 0.002(0.044) | -0.018(0.049) |
| | $R^2$ | 0.057 | 0.049 | 0.055 |
| | Observations | 2710 | 2710 | 2710 |
| 2012-2015 Period | Period | -0.002(0.042) | 0.014(0.036) | 0.002(0.037) |
| | Bottom | 0.022(0.033) | 0.018(0.028) | 0.018(0.034) |
| | 2nd Quintile | -0.04(0.033) | -0.046(0.031) | -0.039(0.03) |
| | 4th Quintile | -0.046(0.026)+ | -0.037(0.025) | -0.03(0.022) |
| | Top | -0.047(0.03) | -0.038(0.027) | -0.033(0.021) |
| | (Period*Bottom) | 0.094(0.052)+ | 0.096(0.045)* | 0.101(0.053)+ |
| | (Period*2nd Quintile) | 0.046(0.048) | 0.046(0.042) | 0.054(0.046) |
| | (Period*4th Quintile) | 0.027(0.036) | 0.014(0.036) | 0.004(0.038) |
| | (Period*Top) | 0.016(0.039) | 0.021(0.032) | 0.016(0.029) |
| | Constant | 0.358(0.371) | 0.402(0.284) | 0.113(0.318) |
| | $R^2$ | 0.048 | 0.057 | 0.058 |
| | Observations | 2924 | 2924 | 2924 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

## Table C3. Difference-in-Difference Regressions from 2006 to 2015: High Socioeconomic Private School (Score)

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | -13.88(16.111) | 2.468(14.179) | -35.149(13.702)* |
| | Bottom | -19.546(9.664)* | -23.017(7.626)** | -14.334(8.779) |
| | 2nd Quintile | -6.862(8.553) | -14.796(9.773) | -13.138(8.453) |
| | 4th Quintile | 11.418(9.615) | 5.695(8.999) | 6.156(9.36) |
| | Top | 31.563(8.704)*** | 20.946(8.546)* | 21.464(9.961)* |
| | (Period*Bottom) | -3.846(13.42) | 1.606(12.408) | -5.429(13.152) |
| | (Period*2nd Quintile) | -15.421(12.589) | -5.405(13.428) | -6.569(13.104) |
| | (Period*4th Quintile) | -20.584(12.32)+ | -11.86(11.621) | -11.345(11.892) |
| | (Period*Top) | -11.157(11.524) | -6.54(10.734) | -6.166(12.054) |
| | Constant | 70.138(109.04) | 143.509(107.384) | 123.381(101.265) |
| | $R^2$ | 0.130 | 0.086 | 0.131 |
| | Observations | 1995 | 1995 | 1995 |
| 2009-2012 Period | Period | 25.002(12.247)* | 2.976(10.744) | 10.187(11.491) |
| | Bottom | -18.895(9.19)* | -17.21(9.362)+ | -16.863(9.296)+ |
| | 2nd Quintile | -23.316(9.379)* | -20.354(8.021)* | -20.11(9.094)* |
| | 4th Quintile | -6.418(7.031) | -3.976(6.52) | -2.481(6.758) |
| | Top | 23.759(8.359)** | 15.947(6.996)* | 18.088(7.173)* |
| | (Period*Bottom) | -8.506(15.676) | -3.435(13.43) | -9.937(13.577) |
| | (Period*2nd Quintile) | -6.999(13.068) | -3.78(12.66) | -5.994(13.56) |
| | (Period*4th Quintile) | 6.099(9.774) | 4.441(8.724) | 4.419(8.32) |
| | (Period*Top) | 1.401(10.514) | -0.388(8.387) | 1.746(9.314) |
| | Constant | -8.506(15.676) | -3.435(13.43) | -9.937(13.577) |
| | $R^2$ | 0.136 | 0.087 | 0.122 |
| | Observations | 2146 | 2146 | 2146 |
| 2012-2015 Period | Period | -50.283(13.928)*** | -31.042(12.887)* | -26.875(13.847)+ |
| | Bottom | -28.626(11.98)* | -21.548(9.393)* | -28.084(10.66)** |
| | 2nd Quintile | -31.348(8.615)*** | -25.114(8.896)** | -26.729(9.227)** |
| | 4th Quintile | -1.134(6.97) | -0.235(5.636) | 1.654(5.734) |
| | Top | 27.544(6.671)*** | 16.734(5.079)*** | 21.784(5.666)*** |
| | (Period*Bottom) | 2.069(16.637) | 1.741(15.973) | 14.803(16.809) |
| | (Period*2nd Quintile) | 27.909(12.434)* | 26.589(12.097)* | 24.939(12.105)* |
| | (Period*4th Quintile) | 27.113(10.991)* | 24.104(8.622)** | 18.653(11.192)+ |
| | (Period*Top) | 25.805(11.563)* | 29.785(10.063)** | 20.657(11.576)+ |
| | Constant | 472.321(111.6)*** | 444.845(95.156)*** | 492.618(104.117)*** |
| | $R^2$ | 0.135 | 0.091 | 0.104 |
| | Observations | 2258 | 2258 | 2258 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

**Table C4. Difference-in-Difference Regressions from 2006 to 2015: High Socioeconomic Private School (Level 1 Proficiency)**

| | | Mathematics | Science | Reading |
|---|---|---|---|---|
| 2006-2009 Period | Period | 0.006(0.019) | -0.013(0.018) | 0.001(0.014) |
| | Bottom | 0.007(0.028) | 0.024(0.028) | 0.012(0.018) |
| | 2nd Quintile | 0.01(0.022) | 0.025(0.026) | -0.004(0.012) |
| | 4th Quintile | 0.005(0.014) | 0.007(0.019) | 0.006(0.012) |
| | Top | -0.01(0.012) | -0.016(0.017) | -0.002(0.011) |
| | (Period*Bottom) | 0.001(0.034) | 0.017(0.046) | 0.011(0.028) |
| | (Period*2nd Quintile) | -0.001(0.029) | -0.004(0.032) | 0.024(0.019) |
| | (Period*4th Quintile) | -0.006(0.02) | -0.008(0.021) | 0.011(0.019) |
| | (Period*Top) | 0.011(0.017) | 0.018(0.02) | 0.007(0.011) |
| | Constant | 0.268(0.197) | 0.222(0.194) | 0.74(0.607) |
| | $R^2$ | 0.024 | 0.026 | 0.040 |
| | Observations | 1995 | 1995 | 1995 |
| 2009-2012 Period | Period | 0.006(0.018) | 0.014(0.016) | 0.025(0.017) |
| | Bottom | 0.004(0.024) | 0.036(0.031) | 0.022(0.02) |
| | 2nd Quintile | 0.01(0.023) | 0.02(0.022) | 0.022(0.018) |
| | 4th Quintile | -0.003(0.015) | -0.003(0.011) | 0.017(0.015) |
| | Top | -0.001(0.013) | 0.001(0.01) | 0.003(0.005) |
| | (Period*Bottom) | 0.039(0.045) | -0.007(0.034) | 0.022(0.045) |
| | (Period*2nd Quintile) | 0.023(0.03) | 0.017(0.03) | 0.02(0.037) |
| | (Period*4th Quintile) | -0.009(0.022) | 0.001(0.018) | -0.025(0.02) |
| | (Period*Top) | -0.012(0.018) | -0.013(0.014) | -0.021(0.014) |
| | Constant | 0.039(0.045) | -0.007(0.034) | 0.022(0.045) |
| | $R^2$ | 0.029 | 0.026 | 0.037 |
| | Observations | 2146 | 2146 | 2146 |
| 2012-2015 Period | Period | 0.069(0.029)* | 0.069(0.031)* | 0.056(0.031)+ |
| | Bottom | 0.042(0.033) | 0.028(0.022) | 0.043(0.042) |
| | 2nd Quintile | 0.032(0.02) | 0.036(0.023) | 0.041(0.03) |
| | 4th Quintile | -0.012(0.015) | -0.002(0.013) | -0.008(0.015) |
| | Top | -0.014(0.012) | -0.013(0.011) | -0.019(0.014) |
| | (Period*Bottom) | -0.018(0.053) | -0.024(0.042) | -0.041(0.054) |
| | (Period*2nd Quintile) | -0.043(0.034) | -0.054(0.035) | -0.054(0.037) |
| | (Period*4th Quintile) | -0.039(0.034) | -0.038(0.03) | -0.029(0.031) |
| | (Period*Top) | -0.051(0.029)+ | -0.046(0.032) | -0.036(0.032) |
| | Constant | -0.016(0.337) | -0.044(0.343) | 0.072(0.295) |
| | $R^2$ | 0.036 | 0.031 | 0.039 |
| | Observations | 2258 | 2258 | 2258 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom, 2nd Quintile, 4th Quintile and Top are dummy variables indicating socioeconomic status (ESCS index) of individuals with the Bottom and Top being the first and fifth quintile groups, respectively, and with them being compared to the third quintile socioeconomic status group. Finally, (Period*Bottom), (Period*2nd Quintile), (Period*4th Quintile), and (Period*Top) variables are interactions of aforementioned variables. All analyses controls for individual- and school-level variables. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate standard errors using the Balanced Repeated Replication method.

## Appendix D

### Table D1. Difference-in-Difference Regressions of Schools in Korea from 2006 to 2015

| | | Scores | | | Proportion of Level 1 Proficiency | | |
|---|---|---|---|---|---|---|---|
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2006-2009 Period | Period | 24.35 | 36.45* | -7.638 | -0.0580 | -0.0948*** | -0.0213 |
| | | (16.16) | (14.99) | (11.68) | (0.0355) | (0.0277) | (0.0242) |
| | Bottom | -66.73*** | -62.63*** | -60.93*** | 0.104* | 0.140** | 0.0936* |
| | | (16.00) | (13.55) | (12.77) | (0.0420) | (0.0456) | (0.0386) |
| | (Period* | -29.96 | -18.66 | -21.73 | 0.0908+ | 0.0530 | 0.100+ |
| | Bottom) | (18.73) | (17.54) | (16.68) | (0.0544) | (0.0567) | (0.0518) |
| | Constant | 582.5*** | 554.2*** | 587.2*** | 0.135* | 0.0893 | 0.0276 |
| | | (32.00) | (29.46) | (23.03) | (0.0572) | (0.0591) | (0.0603) |
| | Observations | 308 | 308 | 308 | 308 | 308 | 308 |
| | $R^2$ | 0.489 | 0.430 | 0.535 | 0.456 | 0.415 | 0.510 |
| | | Scores | | | Level 1 Proficiency | | |
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2009-2012 Period | Period | -19.21 | -21.40 | -5.211 | 0.0524 | 0.0434 | 0.0332 |
| | | (19.10) | (17.28) | (14.29) | (0.0396) | (0.0278) | (0.0254) |
| | Bottom | -87.41*** | -72.96*** | -75.03*** | 0.172*** | 0.167*** | 0.176*** |
| | | (17.85) | (16.16) | (15.17) | (0.0473) | (0.0483) | (0.0474) |
| | (Period* | 46.04* | 40.86* | 47.32* | -0.138* | -0.131* | -0.142* |
| | Bottom) | (23.37) | (19.88) | (20.92) | (0.0585) | (0.0597) | (0.0592) |
| | Constant | 546.2*** | 538.9*** | 530.1*** | 0.215** | 0.127* | 0.103+ |
| | | (36.43) | (30.35) | (25.37) | (0.0685) | (0.0592) | (0.0595) |
| | Observations | 309 | 309 | 309 | 309 | 309 | 309 |
| | $R^2$ | 0.396 | 0.360 | 0.399 | 0.396 | 0.416 | 0.425 |
| | | Scores | | | Level 1 Proficiency | | |
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2012-2015 Period | Period | -25.07+ | -21.74* | -14.60 | 0.0327 | 0.0670* | 0.0434 |
| | | (13.06) | (9.947) | (10.36) | (0.0318) | (0.0270) | (0.0298) |
| | Bottom | -39.75* | -32.72* | -29.57* | 0.0393 | 0.0469 | 0.0520 |
| | | (17.29) | (13.03) | (14.70) | (0.0405) | (0.0331) | (0.0337) |
| | (Period* | -7.873 | -9.938 | -16.36 | 0.0923+ | 0.0706 | 0.0795+ |
| | Bottom) | (17.27) | (14.26) | (15.72) | (0.0500) | (0.0445) | (0.0457) |
| | Constant | 514.0*** | 499.1*** | 486.9*** | 0.299*** | 0.252*** | 0.252*** |
| | | (38.11) | (27.71) | (28.11) | (0.0851) | (0.0718) | (0.0691) |
| | Observations | 321 | 321 | 321 | 321 | 321 | 321 |
| | $R^2$ | 0.273 | 0.285 | 0.279 | 0.271 | 0.330 | 0.300 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom dummy variable indicates schools belonging to the top decile in terms of the proportion of level 1 students of schools. Finally, (Period*Bottom) variable is an interaction of aforementioned variables. All analyses include for school-level controls. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate robust standard errors.

**Table D2. Difference-in-Difference Regressions of Schools in Korea from 2006 to 2015: Score**

| | | Public Schools | | | Private Schools | | |
|---|---|---|---|---|---|---|---|
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2006-2009 Period | Period | 24.83 | 36.15 | -6.601 | 31.26* | 39.62** | -8.348 |
| | | (24.78) | (22.10) | (16.26) | (13.76) | (12.08) | (13.30) |
| | Bottom | -84.85*** | -74.14*** | -73.60*** | -47.42* | -52.09** | -52.82** |
| | | (24.29) | (20.15) | (17.09) | (19.08) | (17.80) | (18.00) |
| | (Period* | -19.81 | -13.56 | -10.95 | -57.24** | -30.45 | -40.25+ |
| | Bottom) | (23.84) | (21.25) | (19.12) | (21.33) | (18.80) | (20.43) |
| | Constant | 592.8*** | 560.1*** | 590.5*** | 570.4*** | 547.1*** | 604.2*** |
| | | (36.79) | (33.74) | (25.43) | (52.19) | (37.35) | (43.52) |
| | Observations | 180 | 180 | 180 | 128 | 128 | 128 |
| | $R^2$ | 0.534 | 0.457 | 0.575 | 0.454 | 0.457 | 0.483 |
| | | Public Schools | | | Private Schools | | |
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2009-2012 Period | Period | -45.71+ | -40.19+ | -18.83 | -2.750 | -11.44 | 1.979 |
| | | (25.91) | (23.14) | (18.40) | (14.47) | (11.23) | (11.38) |
| | Bottom | -82.43*** | -69.17*** | -63.40*** | -93.76*** | -73.51*** | -89.10*** |
| | | (20.50) | (18.99) | (17.16) | (19.04) | (13.89) | (16.84) |
| | (Period* | 76.86** | 70.73*** | 76.20** | 22.81 | 14.23 | 29.04 |
| | Bottom) | (23.23) | (19.95) | (25.39) | (24.40) | (19.21) | (18.98) |
| | Constant | 563.1*** | 545.3*** | 520.6*** | 548.2*** | 543.3*** | 549.3*** |
| | | (43.51) | (37.21) | (31.27) | (31.34) | (23.38) | (20.94) |
| | Observations | 182 | 182 | 182 | 127 | 127 | 127 |
| | $R^2$ | 0.410 | 0.378 | 0.413 | 0.500 | 0.520 | 0.566 |
| | | Public Schools | | | Private Schools | | |
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2012-2015 Period | Period | -7.733 | -12.29 | -2.045 | -48.92** | -32.39* | -30.37* |
| | | (13.61) | (10.31) | (11.13) | (18.21) | (14.64) | (14.26) |
| | Bottom | -12.28 | -7.992 | 3.796 | -64.17** | -52.82** | -54.62*** |
| | | (16.99) | (12.60) | (16.93) | (20.48) | (15.74) | (13.16) |
| | (Period* | -32.45* | -32.83* | -47.74** | 9.432 | 3.517 | 14.33 |
| | Bottom) | (15.38) | (13.15) | (16.37) | (34.52) | (28.02) | (26.38) |
| | Constant | 474.9*** | 473.3*** | 445.2*** | 558.2*** | 524.9*** | 522.3*** |
| | | (44.03) | (31.49) | (31.67) | (38.04) | (30.08) | (28.85) |
| | Observations | 195 | 195 | 195 | 126 | 126 | 126 |
| | $R^2$ | 0.266 | 0.291 | 0.334 | 0.327 | 0.325 | 0.316 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom dummy variable indicates schools belonging to the top decile in terms of the proportion of level 1 students of schools. Finally, (Period*Bottom) variable is an interaction of aforementioned variables. All analyses include for school-level controls. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate robust standard errors.

**Table D3. Difference-in-Difference Regressions of Schools in Korea from 2006 to 2015: Proportion of Level 1 Proficiency**

| | | Public Schools | | | Private Schools | | |
|---|---|---|---|---|---|---|---|
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2006-2009 Period | Period | -0.0674 | -0.107** | -0.0278 | -0.0657* | -0.0781** | -0.0278 |
| | | (0.0544) | (0.0406) | (0.0349) | (0.0284) | (0.0277) | (0.0242) |
| | Bottom | 0.127* | 0.167* | 0.133* | 0.0892+ | 0.128* | 0.0537 |
| | | (0.0626) | (0.0678) | (0.0645) | (0.0524) | (0.0614) | (0.0413) |
| | (Period* | 0.0866 | 0.0578 | 0.0849 | 0.113+ | 0.0181 | 0.110+ |
| | Bottom) | (0.0727) | (0.0763) | (0.0729) | (0.0589) | (0.0624) | (0.0587) |
| | Constant | 0.129* | 0.0737 | 0.00620 | 0.0816 | 0.0882 | 0.0484 |
| | | (0.0639) | (0.0714) | (0.0759) | (0.0748) | (0.0697) | (0.0659) |
| | Observations | 180 | 180 | 180 | 128 | 128 | 128 |
| | $R^2$ | 0.515 | 0.487 | 0.557 | 0.375 | 0.331 | 0.447 |
| | | Public Schools | | | Private Schools | | |
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2009-2012 Period | Period | 0.106+ | 0.0903* | 0.0740* | 0.0319 | 0.00949 | -0.00829 |
| | | (0.0551) | (0.0399) | (0.0347) | (0.0210) | (0.0163) | (0.0213) |
| | Bottom | 0.158** | 0.169** | 0.163** | 0.185*** | 0.135*** | 0.174** |
| | | (0.0536) | (0.0559) | (0.0565) | (0.0364) | (0.0240) | (0.0532) |
| | (Period* | -0.233*** | -0.231** | -0.220** | -0.0565 | -0.0101 | -0.0643 |
| | Bottom) | (0.0637) | (0.0698) | (0.0712) | (0.0500) | (0.0378) | (0.0657) |
| | Constant | 0.212* | 0.125 | 0.128 | 0.109** | 0.0718* | 0.0310 |
| | | (0.0820) | (0.0764) | (0.0800) | (0.0403) | (0.0360) | (0.0440) |
| | Observations | 182 | 182 | 182 | 127 | 127 | 127 |
| | $R^2$ | 0.428 | 0.461 | 0.471 | 0.507 | 0.530 | 0.481 |
| | | Public Schools | | | Private Schools | | |
| | | Mathematics | Science | Reading | Mathematics | Science | Reading |
| 2012-2015 Period | Period | -0.00680 | 0.0466+ | 0.0116 | 0.0916* | 0.100** | 0.0976* |
| | | (0.0351) | (0.0273) | (0.0283) | (0.0393) | (0.0375) | (0.0429) |
| | Bottom | -0.0473 | -0.0224 | -0.0111 | 0.116** | 0.111*** | 0.106** |
| | | (0.0485) | (0.0413) | (0.0410) | (0.0417) | (0.0313) | (0.0319) |
| | (Period* | 0.161*** | 0.131** | 0.137** | 0.0387 | -0.00211 | -0.0116 |
| | Bottom) | (0.0467) | (0.0446) | (0.0481) | (0.112) | (0.0972) | (0.0869) |
| | Constant | 0.431*** | 0.339*** | 0.371*** | 0.152 | 0.124 | 0.100 |
| | | (0.0916) | (0.0776) | (0.0705) | (0.0935) | (0.0887) | (0.0894) |
| | Observations | 195 | 195 | 195 | 126 | 126 | 126 |
| | $R^2$ | 0.336 | 0.418 | 0.420 | 0.249 | 0.257 | 0.245 |

*Note*: Period is a dummy variable indicating year 2009 for the 2006-2009 analysis, indicating 2012 for the 2009-2012 analysis, and indicating 2012 for the 2012-2015 analysis. Bottom dummy variable indicates schools belonging to the top decile in terms of the proportion of level 1 students of schools. Finally, (Period*Bottom) variable is an interaction of aforementioned variables. All analyses include for school-level controls. ***, **, *, + indicate statistical significance at less than 0.1%, 1%, 5%, and 10%, respectively. Numbers in parentheses indicate robust standard errors.

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