Effects of Government's Regulations on Private Education Expenditures in Korea

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The private education market has been expanding in Korea. Hence, various measures at the government level are implemented, such as regulating private educational institutes and strengthening school curricula at all levels. This paper analyzes whether direct regulation on the business hours of private educational institutes is effective in reducing the country's overall private education expenditure. Using the youth panel data of the Korea Employment Information Service from 2007 to 2010, the paper focuses on the regulation of private educational institutes and analyzes the regulation effect on private education expenditures of Korean high school students using Tobit model. Furthermore, the stochastic dominance test is conducted by taking the nonparametric approach of Linton *et al*. (2010). Regulation effects in both approaches vary among the regulated regions.

Keywords: Private education expenditure, Regulation effect, Tobit estimation, Stochastic dominance, Bootstrap

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I. Introduction

The scale of private education[1] expenditures is considerable in Korea. In 2010, private education expenditures reached 20 trillion KRW, but

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[1] Private education should be distinguished from the concept of a private institution's education. The term "private education" refers to all education opportunities that are obtained privately and outside the school, such as private tutoring and private educational institutes.

this value fell by 10% to 18 trillion KRW in 2014.

Using the non-parametric bounding method, Kang (2007) analyzed the effect of private tutoring on student academic performance, and found that private education increased students' grades at school. In comparison, other private education studies reported that private tutoring has negative aspects. For example, Bray (2012) discussed the negative impacts of private tutoring on students in terms of inequalities and inefficiencies brought about by private tutoring. Such inefficiencies occur because private tutoring is difficult to evaluate and tutoring companies in many countries deliberately misrepresent the effectiveness of their work to attract clients (Bray 2012). In terms of inequality, Tansel (2006), and Kim (2009) revealed that people with higher incomes and higher parental educational levels are more likely to pay for private tutoring. Thus, regulating private educational institutes is closely related to economic polarization, given that inequalities in educational opportunities could lead to income inequality.

Several measures can be carried out to reduce private education expenditures in Korea, including strengthening the quality of public education and encouraging students to take Educational Broadcasting System (EBS) lectures.[2] Some researchers have analyzed the effects of the demand for private education on academic performance. For example, Lee (2013) discussed the effects of EBS lectures on academic performance, while Kim, and Lee (2010) examined the relationship between private tutoring and demand for education in Korea with respect to the school equalization policy.[3]

In Korea, private education has six primary types: private teaching institutes, private/group tutoring, after-school curricula, home-study materials, Internet-based tutoring, and TV broadcast tutoring. Private educational institutes have the highest participation rate among the six types. According to KOSTAT (2014), 73% of students receiving private education are educated in private educational institutes. Thus, regulating such institutes can play an important role in reducing private education expenditures.

Korea has a huge private education market. At present, it faces the dilemma of whether regulating private educational institutes is effective

[2] EBS lectures are introduced as a policy for reducing private education expenditures. They are broadcasted through the EBS TV channel (Park 2008).

[3] The equalization policy eliminates competition among secondary schools. One of its objectives is to reduce private tutoring. Kim, and Lee (2010) provide a detailed explanation about the equalization policy.

in reducing the country's excessive educational drive. In 2013, the central government proposed to set the regulation time to 10 pm on private educational institutes throughout the country. This was accomplished by enacting new legislation, instead of a current provincial government ordinance. However, this legislation is difficult to implement because of protests raised by the private teaching institute industry.

The current study focuses on regulations covering the business hours of private educational institutes in light of the government policy movement enacted in 2008.[4] The movement is a measure to solve private education problems. Few studies have analyzed the effects of such regulations on the business hours of private educational institutes.

Kim (2009) applied a panel Tobit model and found that the regulations significantly decreased monthly expenditures on private tutoring and the weekly number of hours of private tutoring from 2005 to 2007. Kim, and Chang (2010) focused on the number of hours spent studying at private educational institutes after the regulation. Moreover, Lee *et al.* (2009) strated the effects of these policies by applying a Tobit model and a Heckman selection model with cross-sectional data.

The present paper analyzes the effect of regulating private educational institutes in relation to reducing private household education expenditures. A non-parametric approach is used to examine the available data. This study also uses Youth Panel panel data, which has not been used in literature, because the data contain considerable information (*i.e.*, household income, parents' education level, or students' academic performance) necessary to analyze private education expenditures. Kim (2009) analyzed the effects of governmental regulations from 2005 to 2007. In comparison, the current paper analyzes data from 2007 until 2010 — the period in which the regulation prevailed over the country. Hence, annual regulation effects are estimated for each region. Previous literature analyzed the effects based on whether a regulation existed. The method of Ai, and Norton (2003) calculated the annual effects in the Tobit model. The method recommends correctly interpreting the interaction terms in the non-linear models.

The present study advances from parametric estimation and uses a non-parametric approach in the analysis. This paper applies the non-parametric approach of Linton *et al.* (2010) and Barrett, and Donald (2003) and tests the stochastic dominance of two distributions: one without regulations and the other with regulations. The method of Linton

[4] The government policy in 2008 can be referred from Kim (2011).

et al. (2010) is used because it allows residuals from non-parametric and semiparametric models to be variables.

Barrett, and Donald (2003) suggested conducting consistent tests with different sample sizes when testing for stochastic dominance. Consequently, a stochastic dominance test is performed with no controls and residuals based on the three regions of Seoul, Busan, and Jeonbuk. Joint hypothesis testing is then devised and conducted to determine whether the regulation has been consecutively effective.

The entire distribution and those below median expenditure were compared in testing stochastic dominance. Choi (2012) noted that income inequality and educational inequality are closely related especially in Korea. Kim (2005) illustrated that educational upgrading has a strong common effect on all age groups such that their wages highly co-move. The goal of regulation on private educational institutes is to lessen the swelling private education market and to narrow down educational inequality, which can lead to long-run economic polarization. Thus, the comparison of the stochastic dominance test results with different weighting functions could reveal regulation effects from a different perspective.

The rest of this article is organized into sections. Section II explains the current state, private education types, and regulations on private educational institutes. The survey data specifics and variables used in the analysis are illustrated in detail. Sections III and IV present the results of the parametric and non-parametric approaches, respectively. Section III presents the Tobit model estimation and analyzes regulation effects using Ai, and Norton's (2003) method. This part discusses the regulation effects by testing residual dominance and stochastic dominance with no control before finally presenting the conclusion.

II. Description of Data

A. Current Regulations on Private Education

KOSTAT (2014) indicated that the participation rate of high school students receiving private education is 49.5%. High school students receive private education at a weekly average of 4.0 hours, while the total annual private education expenditure is 5 trillion KRW. Monthly average private education expenditures are 2.3 thousand KRW per person. About 36.5% of the students receive private education at a private educational institute.

The gap between regions is huge in terms of participation rates and average monthly expenditures. Seoul has the highest participation rate at 61.3%, while other metropolitan areas in the country recorded 50.9%. City areas had 49.2%, while rural areas had 33.2%. The average monthly spending on the private education of high school students currently receiving private education is 371,000 KRW in Seoul, 221,000 KRW in the metropolitan areas, 215,000 KRW in city areas, and 117,000 KRW in rural areas.

The regulation on private educational institutes was one of the policies pushed by then President Myungbak Lee to reduce private education expenses. Some of the results of this policy include the strengthening of the quality of public education and the promotion of EBS lectures.

Lee (2013) analyzed the effects of after-school and EBS internet/ broadcasts on private education expenditures. Park (2008) introduced several policies, such as EBS broadcasts and an after-school system, as a measure to reduce private education expenditures. Kim, and Lee (2010) examined the relationship between private tutoring and the demand for education in Korea with respect to the equalization policy, whereas Lee (2013) discussed the effects of EBS lectures.

The regulation on the number of business hours of private educational institutes is currently being implemented. The regulations on private educational institutes are based on the *Act on the Establishment and Operation of Private Educational Institutes and Extracurricular Lessons*, Article 16(2). The Act was established to soundly develop private educational institutes, extracurricular lessons, and lifelong education. Article 16(2) was added to improve students' health and reduce private education expenses on private educational institutes by regulating their business hours.

The regulation times stipulated in the Act vary from region to region because provincial governments have the autonomy to establish the ordinance and use relevant details. Therefore, some provincial governments organized different regulation times on private educational institutes, which depend on students' education levels (*i.e.*, elementary, middle, and high school). In 2013, the central government set regulation times at 10 pm on private educational institutes throughout the country by enacting the new legislation instead of using the provincial government's ordinance.

The enactment date and relevant details are presented in Table 1. As the regulations are enforced via provincial government ordinance, the enactment dates and the regulation times are different. As can be seen, the regions of interest include Seoul, Busan and Jeonlabukdo, where

TABLE 1
ORDINANCE ON PRIVATE EDUCATIONAL INSTITUTES

Region	Enforcement of Ordinance	Regulation Time
Seoul	Sep. 2009	22:00
Gwangju	Nov. 2010	22:00
Kyunggido	Mar. 2011	22:00
Daegu	Mar. 2011	22:00
Busan	Apr. 2008	23:00
Jeonlabukdo	Aug. 2009	23:00
Incheon	Oct. 2011	23:00
Jeonlanamdo	Nov. 2007	23:50
Chungcheongbukdo	Sep. 2007	24:00
Kyungsangnamdo	Dec. 2007	24:00
Ulsan	Oct. 2008	24:00
Jeju	Jan. 2011	24:00
Daejeon	Feb. 2012	24:00
Kyungsangbukdo	Feb. 2012	24:00
Chungcheongnamdo	Mar. 2012	24:00
Gangwondo	Mar. 2012	24:00

Source: The Act on the Establishment and Operation of Private Educational Institutes and Extracurricular Lessons, Article 16(2), 2006.[5]

the regulations are implemented from 2007 to 2010, and panel survey data are available.

After studying the regulation effect, four regions are found to set a regulation time between 2007 and 2010: Seoul, Busan, Jeonlabukdo, and Ulsan. Ulsan is excluded from the analysis because the number of samples that implemented a 12 pm regulation on private educational institutes is significantly small and may distort the estimation results.

The regulations are considered to be implemented for an entire year regardless of whether they actually started in January of that year. In the annual panel surveys conducted in December of each year, the dependent variable used is the monthly "average" of the private education expenditures; this is presumed to be reflected even if it did not start in January. The enactment dates vary among the regions. Thus, this paper assumes that the regulation effects are reflected in the monthly average expenditures. The only exception is Jeonbuk because this region implemented the regulation in December of 2009. Hence, the regulation

[5] Article 16(2) first entered into force in 2006. The Act on the Establishment and Operation of Private Educational Institutes and Extracurricular Lessons amended by Act No. 7974, Sep. 22, 2006.

in Jeonbuk is considered as implemented in 2010.

In discussing the policy effects, the dependent variable used in the estimation is the total spending on private education. Students are privately educated in a variety of ways. Thus, separating the expenditures on private educational institutes from other types of private education is difficult. For this reason, analyzing the montly private education expenditures of students is more effective than analyzing that of expenditures on private educational institutes. The goal of the expenditure's regulation depends on the reduction of household expenditures on private education.

The total spending on private education decreases if the policy successfully reduces private education expenditures on private educational institutes. However, such expenditures is maintained at a similar level or even increase if the reduction is unsuccessful. Examining whether studends who went to institutes before the regulation actually quit education in any other form (*i.e.*, private tutoring) has become possible because the total private education expenditure is used as a dependent variable.

B. Data

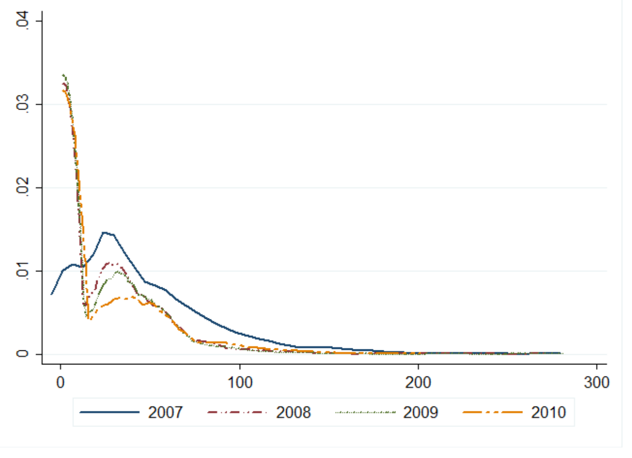
Three surveys are used to collect data on Korean education and private education: 1) Korean education and employment panel (KEEP) data from the Korean Research Institute for Vocational Education and Training, 2) Survey of Private Education Expenditures (SPEE) data from the Korean National Statistical Office, and 3) Youth Panel data from the Korean employment information service.

KEEP and SPEE data are used to analyze regulation effects in previous studies. The two datasets have strengths and weaknesses in analyzing regulation effects. KEEP data are panel data that are available for analyzing private education expenditures in high school students. No high school students remained in the panel between 2007 and 2010.[6] SPEE data contain a large number of samples annually. Hence, the data are cross-sectional and are not suitable for witnessing the regulation effects of students in terms of whether they quit attending the institutes after

[6] KEEP data survey started in 2004. KEEP was only directed at middle school seniors (third grade) and high school seniors. Thus, the panel survey was conducted on all high school graduates since 2007. Consequently, capturing the regulation effects in Kim (2009)'s analysis is possible.

TABLE 2
ANNUAL NUMBER OF OBSERVATIONS IN THE PANEL

Year	Number of Observations	Percentage(%)
2007	2,079	38.94
2008	1,677	31.41
2009	1,076	20.15
2010	507	9.50
Total	5,339	100



Note: This figure shows yearly distribution of private education expenditure. Since 2008, possibly due to the impact of economic recession triggered by subprime mortgage crisis of the United States, overall private education expenditures significantly reduced compared to 2007.

FIGURE 1
KERNEL DENSITY OF PRIVATE EDUCATION EXPENDITURE

the regulation.

Hence, this paper analyzes the Youth Panel data from the Korean employment information service. The data fit the analysis and complements the limitations of KEEP and SPEE data. The Youth Panel is a longitudinal survey that follows up students' transition from school to work (*i.e.*, from adolescence to adulthood). This survey started its second round of panel surveys in 2007. Its biggest advantage is the abundance of information it offers about specific characteristics of individual schools and households. Moreover, private education expenditures are categorized into many different standards (*i.e.*, subject, measure, and the duration of receiving a private education), which are not in the KEEP or SPEE.

This study confines the analysis to high school students, because the main purpose of the regulation is to hinder private education spending arising from the excessive competition surrounding the university entrance exams. The regulation effects are analyzed from 2007 to 2010 because of data availability. The number of observations for each year is presented in Table 2.

The sample size dropped in 2010 because the number of surveyed high school students was higher than that of the surveyed middle school students in the original survey. Korean high school takes three years. Samples of all high school students in the original survey in 2007 were no longer in high school in 2010. Hence, a decrease is found in the sample size.

C. Variables

The variables are chosen according to literature recommendations. Each variable used in the analysis falls into one of four categories: individuals, households, school information, and regulation information. *Gender* and *grade* are individual variables. Gender variable is coded as 1 if a student is male; otherwise, it is coded as 0. Grades reflect the overall results of the most recent exam. They show students' relative ranking in the school and is self-reported by students. The students are evaluated from 1 to 5 with five quantiles. A student who receives a grade within the upper 20% is recorded as a 5, which is the highest number.

The household category includes the number of siblings, father's education level, mother's education level, and average monthly household income. Four categories are set to measure parental education level: 1) lower than high school graduates, 2) equal to high school graduates, 3) equal to junior college graduates, and 4) equal to or higher than university graduates. A high number is given to the high level of educational attainment. Numerical values are used to indicate the number of siblings. Those who are the only child in the family are assigned zero as their sibling variable. Monthly income is an average of the integrated sum of earned income, financial income, income from real estate, and other income; it is measured in units of 10,000 KRW by using the logarithm.

School variables include school types and school locations. The schools are divided into three types: general, specialized, and vocational. Specialized schools consist of foreign language high schools, science schools, and international schools.[7] Vocational schools include agricultural high schools, technical high schools, and commercial high schools. The statistical yearbook of education published by the Korean Educational Development in 2010 states that the college entrance rate of vocational students is 71.5%.

Regulation variables include regional dummies and regulation dummies. Regional dummies include dummy variables for Seoul, Busan, and Jeonbuk. Regulation dummies are constructed as an interaction term of the year and region to estimate the annual regulation effects. Seoul implemented a 10 pm-regulation in 2009, whereas Busan and Jeonlabukdo implemented an 11 pm-regulation in 2008, 2010, respectively.[8]

Moreover, year dummies are included to reflect the country's economic circumstances and compare the regulation effects among the regions. The year dummies are important becasue Korea and other countries went through the financial crisis caused by the subprime mortgage crisis in the United States in 2008. Figure 1 shows a significant decrease from 2008 in the overall distribution of private education expenditures.

The dependent variable, private education expenditures, is the monthly expenditures of all of the subjects spending on private education and is measured in units of 10,000 KRW; the logarithm is then taken. Private education expenditures cover all types of private education that a student receives (*e.g.*, private tutoring); it is not solely from private educational institutes. This is because there are many cases where students receive a private education from private tutors, EBS lectures or private educational institutes at the same time. In addition, as the goal of regulating the business hours of private educational institutes is reducing private education expenditures, it is indirectly possible to distinguish whether other measures of private education (*e.g.*, private tutoring) are considered substitutes for those institutes.

[7] The international school is not a school for foreigners but a school for Korean students.

[8] Private educational institutes need to close by 10 pm or 11 pm.

TABLE 3
DESCRIPTIVE STATISTICS

Variable	Sample	Mean	Std. Dev.	Min	Max
Gender	5,339	1.4781	0.4995	1	2
Grade	5,339	3.4126	0.9393	1	5
Siblings	5,339	1.2697	0.6566	0	6
Father's Edu.Level	5,339	2.6858	1.0259	1	4
Mother's Edu.Level	5,339	2.3337	0.8756	1	4
Income	5,339	5.6722	0.5109	2.3786	7.4191
Location: Seoul	5,339	0.1947	0.3960	0	1
Location: Metropolitan	5,339	0.4210	0.4937	0	1
Location: City	5,339	0.3483	0.4765	0	1
Location: Other	5,339	0.0357	0.1857	0	1
School Type: General	5,339	0.7797	0.4144	0	1
School Type: Specialized	5,339	0.0207	0.1426	0	1
School Type: Vocational	5,339	0.1994	0.3996	0	1
Busan	5,339	0.1146	0.3186	0	1
Jeonbuk	5,339	0.0301	0.1710	0	1
Year dummy: 2007	5,339	0.3893	0.4876	0	1
Year dummy: 2008	5,339	0.3141	0.4642	0	1
Year dummy: 2009	5,339	0.2015	0.4011	0	1
Year dummy: 2010	5,339	0.0949	0.2931	0	1
Reg. Seoul_09	5,339	0.0337	0.1805	0	1
Reg. Seoul_10	5,339	0.0179	0.1328	0	1
Reg. Busan_08	5,339	0.0367	0.1880	0	1
Reg. Busan_09	5,339	0.0235	0.1518	0	1
Reg. Busan_10	5,339	0.0097	0.0982	0	1
Reg. Jeonbuk_10	5,339	0.0037	0.0610	0	1
Private Edu. Expenditure	5,339	2.2612	1.8516	0	5.6380

Note: The Gender variable of male students is set to zero, whereas that of female students is set to one. The values of grade are evaluated according to the five quantiles. Income is monthly household income with unit 10,000 KRW and is taken as a logarithm. Parents' education level is evaluated with four levels.

III. Parametric Approach: Tobit Estimation

A. Estimation Results

The results of the Tobit estimation are illustrated in Table 4. Female students were likely to receive private education more frequently than male students. Moreover, students with low grades were unlikely to receive private education compared with students that obtained better grades.

TABLE 4
PANEL TOBIT MODEL RESULTS

Variable	Coefficient	Std. Err.	z	$P>\|Z\|$
Female	0.1878	0.0750	2.50	0.012
Grade	0.1763	0.0369	4.77	0.000
Siblings	-0.2555	0.0598	-4.27	0.000
Father's Edu Level	0.2484	0.0465	5.34	0.000
Mother's Edu Level	0.1151	0.0534	2.16	0.031
Income	0.8390	0.0776	10.80	0.000
Loc_2	-0.4531	0.1142	-3.97	0.000
Loc_3	-0.4625	0.1117	-4.14	0.000
Loc_4	-1.3555	0.2337	-5.80	0.000
Type_2	0.3163	0.2502	1.26	0.206
Type_3	-1.8400	0.1037	-17.73	0.000
Busan	0.1787	0.1652	1.08	0.279
Jeonbuk	-0.5270	0.2383	-2.21	0.027
Reg. Seoul _09	0.6612	0.2010	3.29	0.001
Reg. Seoul_10	0.5423	0.2789	1.94	0.052
Reg. Busan_08	-0.8574	0.2261	-3.79	0.000
Reg. Busan_09	-0.4573	0.2753	-1.66	0.097
Reg. Busan_10	-1.2735	0.4375	-2.91	0.004
Reg. Jeonbuk_10	-0.0643	0.6087	-0.11	0.916
dum. 2008	-1.9567	0.0752	-26.00	0.000
dum. 2009	-2.4709	0.1002	-24.66	0.000
dum. 2010	-2.7959	0.1450	-19.28	0.000
Constant	-2.3018	0.4584	-5.02	0.000
sigma_u	1.2160	0.0456	26.63	0.000
sigma_e	1.8650	0.0319	58.29	0.000

Both father's and mother's education levels were positively significant to the private education expenditure. Hence, father's education level had more impact on private education level compared with that of the mother. Moreover, private education expenditures decreased with the increase in the number of siblings.

Income and expenditures were positively correlated. Hence, private education expenditures increased with a rise in household income. This finding supports the results of Tansel (2006) and Kim (2009) who reported that parents' high incomes and high parental educational levels help provide more resources to obtain private tutoring.

Seoul had the highest average private education expenditures among city-level regions. Average expenditures on private education varied depending on the size of the cities. That is, the bigger the city is, the higher the private education expenditures are spent. Meanwhile, the counties

(Gun regions) had low expenditures on private education. The difference between Seoul and the counties was the largest compared with other regions because of two possible reasons. First, more private educational institutes are found in a big city than in a small town. Second, the level of competitiveness enables students in a big city to receive private education.

Regarding the school type, specialized schools spent more money on private education. On the one hand, people who attend specialized schools (*e.g.*, science high schools and foreign language high schools) are selected by their entrance exams. Thus, students undergo keen competition when entering college. On the other hand, students at vocational schools spent much less money on private education considering the fact that vocational schools focused more on getting a job after graduation rather than going to college.

B. Regulation Effects

The analysis of interest is about the regulation effect, and focus is placed on regional differences. Table 5 presents regulation effects by calculating marginal effects.[9] Table 5 shows that the effects of regulation on private educational institutes vary depending on the regions.

Private education expenditures in Seoul increased even with the regulations in 2009, 2010. In addition, the regulation effects in Busan and Jeonbuk reduced private education expenditures. The regulation effects were statistically significant in 2008 and 2010 but were insignificant in 2009. A reduction in private education expenditures is shown despite the difference in the reduced amount of expenditures. The coefficient of Jeonbuk's regulation in 2010 showed a statistically insignificant reduction in private education expenditures. The results imply that regulation on private educational institutes play an important role in the reduction of private education expenditures when controlling for other possible factors.

Aside from the annual difference of increased/decreased private education expenditures in the same region, two possible explanations for regional differences can be presented. First, the participation rate of receiving a private education at institutes varies among the regions. The participation rate in Seoul is 61.3%, which is the highest among the three regions, while those in Busan and Jeonbuk are 50.9% and 37.5%,

[9] Interaction effects are computed following Ai, and Norton (2003) because the Tobit model is a non-linear model.

TABLE 5
REGULATION EFFECTS FROM PANEL TOBIT ESTIMATION

Variable	Delta-method			$P>\|Z\|$	[95% CI]	
	dy/dx	Std. Err.	z			
Seoul 2009	0.6232	0.0531	11.72	0.000	0.5190	0.7275
Seoul 2010	0.0588	0.0955	6.16	0.000	0.4012	0.7756
Busan 2008	-0.2699	0.0730	-3.70	0.000	-0.4131	-0.1267
Busan 2009	-0.1035	0.0811	-1.28	0.202	-0.2626	0.0555
Busan 2010	-0.1633	0.0411	-3.97	0.000	-0.2440	-0.0827
Jeonbuk 2010	-0.0540	0.0862	-0.63	0.531	-0.2230	0.1150

Note: Regulation effects are calculated by marginal effects based on panel Tobit estimation. dy/dx with variables marked with a star (*) is for the discrete change of dummy variable from 0 to 1.

respectively. Thus, the difference in the participation rate could explain why the regulation in Busan is more effective than that in Jeonbuk. The regulation effect should be the largest given that the par- ticipation rate of attending private educational institutes is the highest in Seoul. However, regional characteristics, such as the population and regional income, should not be underestimated.

To explain Seoul's regulation effect, the regional characteristics must be discussed. In terms of the population and regional income characteristics, the scale of the three regions implies a size difference. Seoul, the capital city of Korea, has a population of approximately 10 million people. Busan's population is 3.5 million, while Jeonbuk's population is only about 1.9 million.[10] Considering both the population and participation in private education, Seoul has a larger private education market, compared with the other regions. In other words, even if private educational institutes are regulated by restricting the business hours, many other substitutes are available. Hence, instead of receiving private education at private education institutes, the transfer to other means of private education among the students may have occurred. Such transfer may result in an increase in private education expenditures.

IV. Nonparametric Approach: Testing Stochastic Dominance

Following the Tobit model estimation, the regulation effect on private

[10] These data are based on the KOSTAT Survey in 2014.

education expenditures is analyzed with the non-parametric approach of the first-order and second-order stochastic dominance. The analysis used the bootstrap method established in Linton *et al.* (2010) and Barrett, and Donald (2003). This method is applied to possibly measure the regulation effect by testing the stochastic dominance of the two groups, private education expenditures in a regulated year and unregulated year for each region, with the distribution below the median and the entire distribution. By comparing the results with the different weighting functions, the regulation effects can be analyzed as to whether the overall expenditures decreased or only the expenditures below the median decreased. Furthermore, this paper shows the results of the stochastic dominance test with the joint hypothesis to determine whether the regulations were consecutively effective after implementing the regulations.

A. Stochastic Dominance with No Control

In this section IV, the stochastic dominance is tested with the nominal private education expenditure values without controlling for any other variable. The Cumulative Distribution Functions (CDFs) of each comparison group is illustrated in Figure 2. The control group throughout the stochastic dominance test is the group of students before the regulation, while the treatment group is the group of students after the regulation. The first comparison group is the pooled sample of no regulation *versus* the regulated sample, regardless of the region. The second group is Seoul's CDF between 2008 (before the regulation) and 2010 (after the regulation) as Seoul imposed its regulation in 2009. The third group is Busan's private education expenditures between 2007 and 2009 as Busan implemented the regulation in 2008. The last group is the sample from Jeonbuk between 2009 and 2010, which reflects the start of the regulation of the Jeonbuk area in 2010.

a) First-Order Stochastic Dominance

The results of the first-order stochastic dominance testing are presented in Table 7. In the cases where $w(x)=1\{x \leq \mu\}$, the null hypotheses for all of the cases except Jeonbuk are not rejected in Test 1. In the pooled case, the results show that the null hypothesis is not rejected in Test 1. However, it is rejected in Test 2. Hence, the regulation has been effective in the pooled sample. However, in the case of Seoul, none of the null hypotheses were rejected. This implies a weak stochastic dominance in this region. This finding corresponds to the Tobit esti-

TABLE 6
DESCRIPTIVE STATISTICS OF EACH COMPARING GROUP

Case		Sample	Mean	Std. Dev.	Median
Pooled	No Reg.	4,669	30.0791	34.8433	22
	Reg.	344	31.5698	36.3207	30
Seoul	No Reg.	344	31.5698	36.3207	30
	Reg.	96	36.6771	43.0516	30
Busan	No Reg.	238	34.0630	32.8359	25
	Reg.	126	12.0714	19.7732	0
Jeonbuk	No Reg.	34	8.8235	16.4325	0
	Reg.	20	8.3500	16.8500	0

Note: Pooled case is combined regulated group and unregulated group. In Seoul's case, regulated group is from 2010 and unregulated group is from 2008. Likewise, Busan's regulated group is in 2009 while its unregulated group is from 2007. Lastly, Jeonbuk's comparing years are 2009 and 2010.

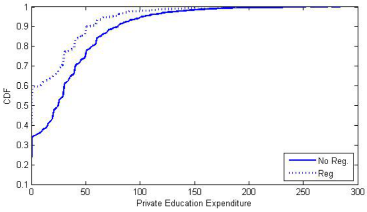
TABLE 7
FIRST-ORDER STOCHASTIC DOMINANCE WITH NO CONTROL

Case	Value of c	Test 1		Test 2	
		WF 1	WF 2	WF 1	WF 2
Pooled	3.0	0.640	0.990	0.000	0.000
	3.5	0.642	0.994	0.000	0,000
	4.0	0.656	0.990	0.000	0.000
Seoul	2.0	0.500	0.116	0.216	0.636
	2.5	0.492	0.114	0.234	0.622
	3.0	0.476	0.090	0.208	0.592
Busan	3.0	0.700	0.972	0.000	0.000
	3.5	0.726	0.980	0.000	0.000
	4.0	0.694	0.972	0.000	0.000
Jeonbuk	0.01	0.000	0.258	0.000	0.254
	0.02	0.000	0.296	0.000	0.328
	0.05	0.000	0.450	0.000	0.458

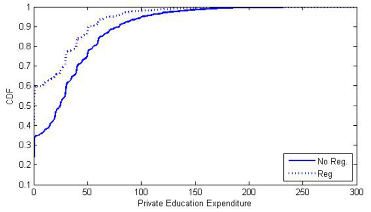
Note: WF1 refers to $w(x) = 1\{x \leq \mu\}$. WF 2 refers to $w(x) = 1$. The number of bootstrap is 500. The value of c determines the size of a contact set.

mation result in that the regulation has not been effective.

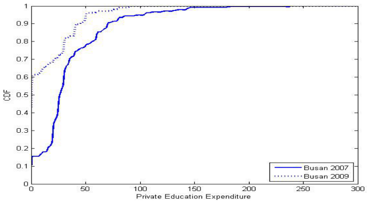
The P-values for Busan are the highest among the presented cases in Test 1. They are all zeros in Test 2. Therefore, the regulation on private



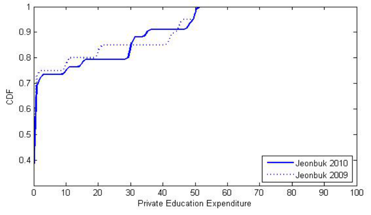
[Pooled]



[Seoul]



[Busan]



[Jeonbuk]

Note: The figures above are the empirical CDFs of each case. Seoul implemented the regulation in 2009, while Busan and Jeonbuk implemented theirs in 2008 and 2010, respectively.

FIGURE 2

EMPIRICAL CDFS OF PRIVATE EDUCATION EXPENDITURE

educational institutes is effective. In Jeonbuk, the results of the first-order stochastic dominance testing are quite different with the weighted functional forms. With the weighted function 1 ($w(x)=1\{x \leq \mu\}$), the null hypothesis is rejected in both tests. Given the ambiguous conclusion about the regulation effect in this case, which group dominates the other remains uncertain. With the entire distribution, both null hypotheses are not rejected. Hence, a weak stochastic dominance exists in the Jeonbuk area, implying that the regulation effects are minimal or non-existant.

As seen in the result of the first-order stochastic dominance Tests 1 and 2, the unregulated group stochastically dominates the regulated group for the pooled and Busan case. In Seoul, where a single crossing in the CDFs occurs, each group (unregulated and regulated) weakly dominates the other. Whether any group stochastically dominates the other in Jeonbuk remains unclear.

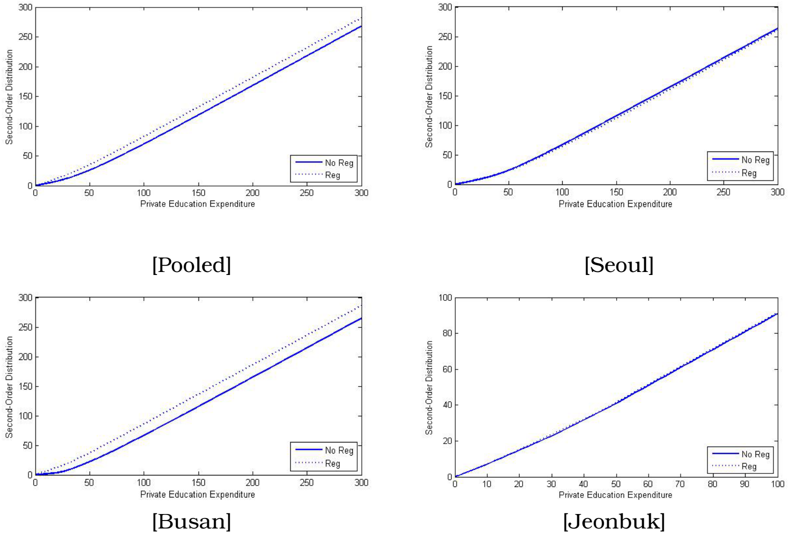
TABLE 8
SECOND-ORDER STOCHASTIC DOMINANCE WITH NO CONTROL

Case	Value of c	Test 1		Test 2	
		WF 1	WF 2	WF 1	WF 2
Pooled	40	0.520	0.196	0.000	0.000
	45	0.584	0.254	0.000	0.000
	50	0.548	0.654	0.000	0.000
Seoul	8.0	0.490	0.084	0.190	0.562
	9.0	0.522	0.104	0.212	0.518
	10.0	0.526	0.106	0.208	0.588
Busan	30	0.540	0.220	0.000	0.000
	35	0.566	0.236	0.000	0.000
	40	0.570	0.248	0.000	0.000
Jeonbuk	1.0	0.000	0.574	0.000	0.480
	2.0	0.000	0.602	0.000	0.510
	5.0	0.000	0.618	0.000	0.484

Note: $D_0=\int_{-\infty}^{x}F_0dx$ and $D_1=\int_{-\infty}^{x}F_1dx$. The number of bootstrap is 500. WF1 refers to $w(x)=1\{x\leq\mu\}$, and WF 2 refers to $w(x)=1$. The value of c determines the size of a contact set.

b) Second-Order Stochastic Dominance

In addition to testing the first-order stochastic dominance, the second-order stochastic dominance is tested. The test results are shown in Table 8. The results of the second-order stochastic dominance tests are similar with those of the first-order stochastic dominance. As seen in the compatible results of Tests 1 and 2, the pooled and Busan cases show that the regulation is effective in reducing private education expenditures. The noticeable point in this testing is the Seoul and Jeonbuk region. In the previous first-order SD test, the dominance between the two comparison groups in Seoul is weak. However, the regulation proved to be ineffective at the 10% level, when the value of c is 8, and the values are uniformly weighted. Moreover, in Jeonbuk, the results of the second-order stochastic dominance tests are noticeable in that they show the opposite results, depending on the weight of the functional form. When testing with $w(x)=1\{x\leq\mu\}$, both Tests 1 and 2 are rejected. Hence, the existence of dominance is uncertain. Meanwhile, with $w(x)=1$, both tests are not rejected, implying that each group weakly dominates the other.



[Pooled] [Seoul]

[Busan] [Jeonbuk]

Note: Each figure illustrates the second-order distribution without control. In the pooled case, the comparison groups involve whether regulation is present or not. The years being compared in Seoul are 2008 (before regulation) and 2010 (after regulation); those in Busan are 2007 (before regulation) and 2009 (after regulation); and those in Jeonbuk are 2009 and 2010.

FIGURE 3
SECOND-ORDER DISTRIBUTIONS WITH NO CONTROL

B. Residual Dominance

In this section, a dominance test is performed with the residuals, based on the results of the pooled OLS estimation. As the residuals from the Tobit estimation results are not applicable inthe stochastic dominance test due to its non-linear aspect, the pooled OLS are used for all other factors. As shown in Table 9, most of the pooled OLS estimation results are statistically significant. The results of the stochastic dominance test are quite different from the previous analysis with no control.

a) First-Order Stochastic Dominance

Before discussing the test results, the CDFs of each group are presented in Figure 3. Multiple crossings in the CDFs can also be seen in the figure. The results of the first-order stochastic dominance of the

TABLE 9
POOLED OLS ESTIMATION RESULTS

Variable	Coefficient	Std. Err.	t	$P>\|t\|$
Female	0.0943	0.0418	2.25	0.024
Grade	0.1278	0.0223	5.72	0.000
Siblings	-0.1462	0.0320	-4.56	0.000
Father's Edu Level	0.1576	0.0262	6.02	0.000
Mother's Edu Level	0.0947	0.0302	3.13	0.002
Income	0.6074	0.0442	13.72	0.000
Loc_2	-0.3716	0.0690	-5.38	0.000
Loc_3	-0.3556	0.0675	-5.26	0.000
Loc_4	-0.9310	0.1266	-7.35	0.000
Type_2	0.2902	0.1467	1.98	0.048
Type_3	-1.0668	0.0547	-19.47	0.000
Busan	0.0678	0.1092	0.62	0.534
Jeonbuk	-0.3950	0.1328	-2.97	0.003
Reg. Seoul_09	0.3669	0.1400	2.62	0.009
Reg. Seoul_10	0.3292	0.1859	1.77	0.077
Reg. Busan_08	-0.4148	0.1552	-2.67	0.008
Reg. Busan_09	-0.1756	0.1795	-0.98	0.328
Reg. Busan_10	-0.4333	0.2489	-1.74	0.082
Reg. Jeonbuk_10	0.0335	0.3721	0.09	0.928
dum. 2008	-1.3279	0.0528	-25.12	0.000
dum. 2009	-1.5892	0.0666	-23.83	0.000
dum. 2010	-1.7381	0.0909	-19.12	0.000
Constant	-0.6921	0.2614	-2.65	0.008

Note: Busan and Jeonbuk dummies are included to estimate the regulation effects of Busan, Jeonbuk, and Seoul (Seoul dummy is Loc_1 dummy; however, it is omitted in the estimation due to multicollinearity problem with Loc_2, Loc_3, and Loc_4). Each regulation dummy is an interaction term of regulating year and regional dummy.

residuals are presented in Table 11. Depending on the weighting functions, the results of these tests are noted to be different.

In the pooled case, while the regulation is shown to be effective with the use of the weighting function $w(x)=1\{x\leq\mu\}$, the dominance with the use of the uniformly weighted function is uncertain as both null hypotheses are rejected. This difference in the results is also revealed in Seoul. Although no dominance is found in the other cases of the Seoul region at the 5% level, the regulation can be concluded to be effective with WF 1. From this result, the regulation is proven to be effective among private education spending under the median, while its effect is ambiguous with all expenditures on private education.

TABLE 10

DESCRIPTIVE STATISTICS OF RESIDUALS

Case		Sample	Mean	Std. Dev.	Median
Pooled	No Reg.	4,669	-0.0061	1.4923	0.2358
	Reg.	670	0.0140	1.6488	-0.1782
Seoul	No Reg.	764	-0.0129	1.4555	0.3473
	Reg.	276	0.0000	1.7293	0.5946
Busan	No Reg.	238	0.0035	1.2795	0.3169
	Reg.	374	0.0000	1.5361	-0.4842
Jeonbuk	No Reg.	141	-0.0093	1.3445	-0.2193
	Reg.	20	0.0000	1.4638	-0.6133

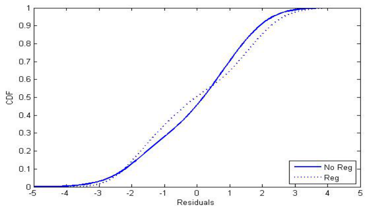
Note: Likewise, each comparing group is identical to that of Table 6. Residuals are obtained from conducting Pooled OLS estimation. Except Pooled case (Case 1), Pooled OLS is conducted without location dummies (Loc_2, Loc_3, Loc_4, Busan, and Jeonbuk) and regulation dummies (Since I divide the residuals depending on the existence of regulation).

TABLE 11

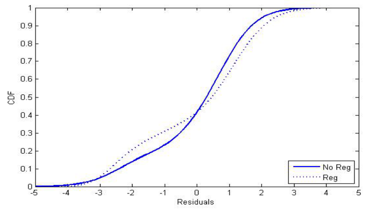
FIRST-ORDER STOCHASTIC DOMINANCE WITH RESIDUALS

Case	Value of c	Test 1		Test 2	
		WF 1	WF 2	WF 1	WF 2
Pooled	0.5	0.304	0.000	0.000	0.000
	0.7	0.308	0.002	0.000	0.002
	1.0	0.310	0.006	0.000	0.008
Seoul	0.3	0.256	0. 000	0.002	0.000
	0.5	0.380	0.002	0.004	0.004
	0.7	0.400	0.016	0.022	0.016
Busan	0.5	0.052	0.000	0.000	0.000
	0.7	0.052	0.000	0.000	0.000
	1.0	0.068	0.000	0.000	0.000
Jeonbuk	0.1	0.198	0.056	0.078	0.020
	0.3	0.308	0.296	0.176	0.226
	0.5	0.322	0.308	0.166	0.260

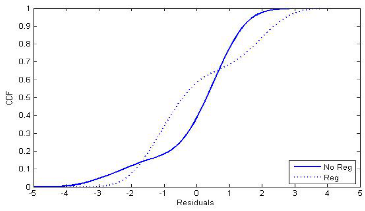
Note: This table shows P-values from the results of first-order stochastic dominance test with residuals. WF 1 refers to $w(x) = 1\{x \leq \mu\}$, and WF 2 refers to $w(x) = 1$. The number of bootstrap is 500. The value of c determines the size of a contact set.



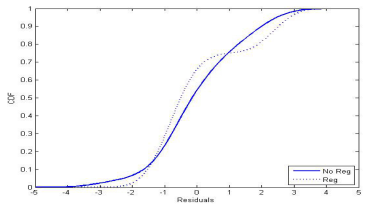
[Pooled]



[Seoul]



[Busan]



[Jeonbuk]

Note: Each figure shows the CDF of residuals from Pooled OLS estimation. This finding is for testing first-order stochastic dominance. In the pooled case, the groups being compared involve whether regulation is present or not. The years being compared in Seoul are 2008 (before regulation) and 2010 (after regulation); those in Busan are 2007 (before regulation) and 2009 (after regulation); and those in Jeonbuk are 2009 and 2010.

FIGURE 4

CDFS OF RESIDUALS FROM POOLED OLS ESTIMATION

The test results of Busan's regulation are not only distinct as to the difference in the weighting functions, but also distinct as to the previous analysis (stochastic dominance with no control). When applying WF1, the regulation is found to be effective at the 5% level by comparing the results of Tests 1 and 2. However, even though regulation in Busan has been shown to be effective in both of the weighted functional forms in Section IV. A, the effectiveness of the regulation with WF 2 is unclear in all of the tested values of c as both hypotheses are rejected. As the estimation results are very sensitive to the value of c, the results of the stochastic dominance test are also different in Jeonbuk. When c is 0.1, a regulation effect in Jeonbuk is observed for both the weighting functions at the 10% and 5% levels.

TABLE 12
SECOND-ORDER STOCHASTIC DOMINANCE WITH RESIDUALS

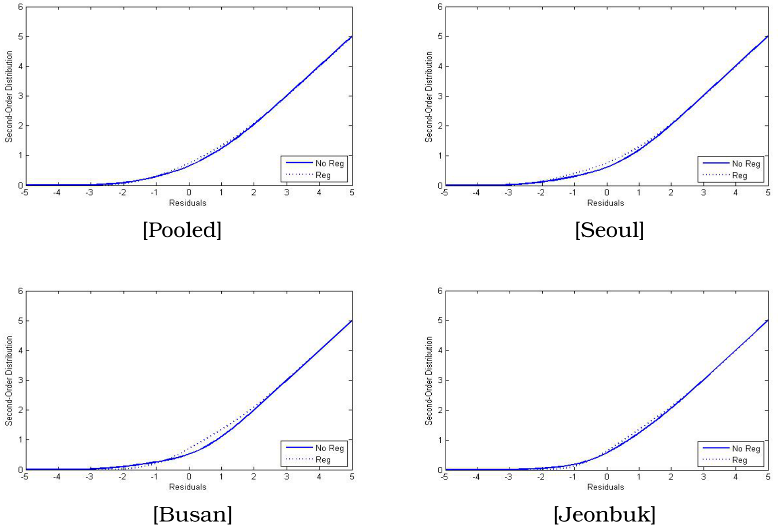
Case	Value of c	Test 1		Test 2	
		WF 1	WF 2	WF 1	WF 2
Pooled	0.5	0.254	0.450	0.000	0.192
	0.7	0.262	0.430	0.004	0.184
	1.0	0.268	0.438	0.006	0.154
Seoul	0.5	0.432	0.524	0.000	0.198
	0.7	0.434	0.542	0.000	0.208
	1.0	0.442	0.550	0.002	0.200
Busan	0.5	0.026	0.342	0.044	0.116
	0.7	0.072	0.374	0.114	0.112
	1.0	0.084	0.414	0.120	0.120
Jeonbuk	0.1	0.000	0.438	0.334	0.418
	0.3	0.174	0.476	0.690	0.464
	0.5	0.196	0.478	0.668	0.470

Note: This table shows P-values from the results of second-order stochastic dominance test with residuals. $D_0 = \int_{-\infty}^{x} F_0 dx$ and $D_1 = \int_{-\infty}^{x} F_1 dx$ The number of bootstrap is 500. WF1 refers to $w(x) = 1\{x \leq \mu\}$, and WF 2 refers to $w(x) = 1$. The value of c determines the size of a contact set.

b) Second-Order Stochastic Dominance

The second-order distributions are depicted in Figure 5. The test results are presented in Table 12. With respect to the pooled case, while the regulation is shown to be effective under WF 1, the dominance is weak with WF 2. This result is different from that of stochastic dominance with no control. Likewise, Seoul's stochastic dominance test of regulation is similar to the pooled case. Under the weighting function $1\{x \leq \mu\}$, the results of Tests 1 and 2 imply that the regulation is effective. However, under WF 2, each comparing group weakly dominates the other in Seoul.

In particular, Busan's results show the effectiveness of the regulation compared with the stochastic doimnance test with no control. In the previous section, although the regulation is shown to be effective in all weighted functional forms, it is only effective with WF 1 at the 5% level for the 0.7 and 1.0 values of c and at the 1% level when c is 0.5. Finally, in Jeonbuk, when c is 0.1 and the weighting function is $1\{x \leq \mu\}$, the regulated group stochastically dominates the unregulated group. This finding implies that the regulation is not effective. Except for that



Note: Each figure shows a second-order distribution of residuals from Pooled OLS estimation. In the pooled case, the groups being compared involve whether regulation is present or not. The years being compared in Seoul are 2008 (before regulation) and 2010 (after regulation); those in Busan are 2007 (before regulation) and 2009 (after regulation); and those in Jeonbuk are 2009 and 2010.

FIGURE 5

SECOND-ORDER DISTRIBUTIONS OF RESIDUALS

particular specification, stochastic dominance is weak in Jeonbuk.

C. Joint Hypothesis Testing

a) Seoul Region

Given that Seoul imposed regulations on private educational institutes in 2009, the dominance test is conducted for data from 2008 through 2010 (*i.e.*, 2008 *vs.* 2009 and 2008 *vs.* 2010). The stochastic dominance in Seoul differs according to the weighting function. Particularly, in testing the stochastic dominance with no control, each group weakly dominates each other with WF 1. However, the results of the regulation effects differ by the uniformly weighted function, along with the specification of the value *c*. When $c_1=0.05$ and $c_2=0.10$, the regulation is ineffective as the null of Test 1 is rejected, and the null of Test 2 is not

TABLE 13
JOINT HYPOTHESIS: FIRST-ORDER STOCHASTIC DOMINANCE WITH NO CONTROL

Case	Value of c		Weight Function			
			$w(x)=1\{x \le \mu\}$		$w(x)=1$	
	c_1	c_2	Test 1	Test 2	Test 1	Test 2
Busan	0.1	0.1	0.830	0.000	0.652	0.000
	0.2	0.2	0.834	0.000	0.774	0.000
	0.5	0.5	0.842	0.000	0.892	0.000
Seoul	0.05	0.10	0.242	0.240	0.032	0.052
	0.07	0.12	0.258	0.290	0.054	0.038
	0.10	0.15	0.290	0.398	0.062	0.042

Note: This table shows P-values after conducting First-Order SD test with residuals. In case of Busan when $w(x)=1\{x \le \mu\}$, I integrated over large X instead of contact set $\hat{B}$ (as $\hat{B}$ is an empty set for that case). The number of bootstrap is 500.

TABLE 14
JOINT HYPOTHESIS: FIRST-ORDER STOCHASTIC DOMINANCE WITH RESIDUALS

Case	Value of c		Weight Function			
			$w(x)=1\{x \le \mu\}$		$w(x)=1$	
	c_1	c_2	Test 1	Test 2	Test 1	Test 2
Busan	0.5	0.5	0.924	0.000	0.984	0.000
	0.7	0.7	0.940	0.000	0.992	0.000
	1.0	1.0	0.950	0.000	0.996	0.002
Seoul	0.01	0.10	0.682	0.006	0.806	0.154
	0.02	0.12	0.702	0.096	0.822	0.150
	0.05	0.15	0.796	0.174	0.846	0.274

Note: This table shows P-values after conducting First-Order SD test with residuals. The number of bootstrap is 500.

rejected. However, Seoul's regulation on private educational institutes, except for the case with a uniformly weighted function, is shown as effective.

The results of testing the stochastic dominance with the residuals are almost opposite to those with no control. With the weighting function using the median, the regulation is effective except for the case where $c_1=0.05$ and $c_2=0.15$. In the case where $c_1=0.05$ and $c_2=0.15$, the stochastic dominance is obscure between the two groups. When comparing the groups with a uniformly weighted function, the regulation effect is uncertain in Seoul.

b) Busan Region

The years that are compared in Busan are 2007 *vs*. 2008 and 2007 *vs*. 2009. Under the joint hypotheses, the regulation is effective for all specifications of the value c (the size of a contact set) in both tests of stochastic dominance with no control and with the residuals, regardless of the forms of a weighting function. Therefore, as observed in the previous sections, despite the variation of the comparison for each year of the regulation effects in Busan, the regulation became effective after implementing the regulation policy in 2008 (Table 13 and 14).

While Seoul's regulation effects are difficult to state owing to the different effectiveness levels of the regulation in the region, Busan's regulation on private educational institutes has been effective in reducing private education expenditures, depending on the specification of the size of a contact set. This finding can be see from the compatible results of Tests 1 and 2 for the SD test with no control and the test with the residuals.

V. Conclusion

With the expansion of the private education market in Korea, various measures have been taken at the government level to decrease these private education expenditures (*e.g.*, regulations on private educational institutes and strengthening the curricula at schools). Among these measures, this paper analyzes whether the direct regulation on private educational institutes' business hours is effective in reducing the country's overall private education expenditures.

In this regard, this paper analyzes the regulation effects for three Korean regions, where the regulations are implemented from 2007 to 2010. By applying the Tobit model with random effects, the regulation effects are shown to be different from region to region. In Busan, the effect of a regulation is statistically significant in reducing the private education expenditures. In Seoul, the regulation is minimal, or rather, increases private education expenditures. In Jeonbuk, a reduction of private education expenditures can be observed, but is not statistically significant.

In addition to the Tobit model estimation, a first-order and second-order stochastic dominance testing is introduced as a non-parametric approach. This method is significant as it allows for the comparison of the distributions of private education expenditures with differently weighted functional forms. In particular, the bootstrap method of Linton *et al.* (2010) and Barrett, and Donald (2003) is used to determine the stochastic dominance between the regulated and unregulated groups. According to the estimation results, the regulation of private educational institutes is shown to be effective, especially in Busan. Its effect is different in other regions under each specification. The stochastic dominance test with residuals are shown to be compatible with the Tobit estimation results.

In conclusion, although policy makers can use various measures to alleviate education inequality within the private education market, regulations on private educational institutes' business hours can be applied to effectively resolve the problem. Although this regulation could result in less education inequality for students and the prevention of more economic polarization due to education inequality, it should be carefully implemented as the regulation is effective only in Busan, but not in Seoul and Jeonbuk.

In Korea, four regions (*i.e.*, Seoul, Busan, Jeonbuk, and Ulsan) have undergone regulation from 2007 to 2010. Seven regions are regulating private educational institutions in 2015. For future studies that aim to analyze the regulation effect, additional surveys must be conducted to avoid attrition problems in the number of samples. As the regulation on private educational institutes at the national level is being discussed, it is recommended that more research be conducted on its effects on other regions or other levels of students, such as elementary and middle school students.

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Appendix: Test statistic and Bootstrap

As the two sample sizes are not equivalent, I use the modified test statistic of Linton *et al.* (2010) as follows.[11] M is the sample size of X_0 and N is the sample size of X_1.

$$T_N \equiv \int_{\chi} \max\left\{\sqrt{\frac{MN}{M+N}}\bar{D}_{01}(x), 0\right\}^2 w(x)\mathrm{d}x, \tag{1}$$

where $\bar{D}_{01}^{(1)}(x, \theta, \tau) \equiv \bar{F}_0(x) - \bar{F}_1(x)$, $\bar{D}_{01}^{(2)}(x, \theta, \tau) \equiv \int_{-\infty}^{x} \bar{D}_0(t, \theta, \tau)\mathrm{d}t - \int_{-\infty}^{x} \bar{D}_1(t, \theta, \tau)\mathrm{d}t$

$\bar{D}_{01}^{(1)}$ refers to the difference between CDF of X_0 and X_1 when testing first-order stochastic dominance. When testing the second-order stochastic dominance, $\bar{D}_{01}^{(2)}$ is used as presented above. The weight function $w(x)$ is analyzed with two forms: $w(x)=1\{x \leq \mu\}$ and $w(x)=1$. This is done to capture overall regulation effect as well as regulation effect on people spending below-median expenditure. The hypotheses are presented below.

$$H_0 : D_{01}(x) \leqq 0 \quad \text{for all} \quad x \in \chi,$$
$$H_1 : D_{01}(x) > 0 \quad \text{for some } x \in \chi$$

In testing stochastic dominance, I also conduct the test under the null hypothesis, which is the opposite direction of null hypothesis suggested above.[12] The test performed under the above hypothesis will be called as Test 1 and the test performed under the latter will be called as Test 2 in the analysis. To conduct inferences from the limiting distribution, bootstrap method is used in this paper. The bootstrap test statistic is also a modified test statistic, which comes from the different sample sizes of X_0 and X_1.

[11] Barrett, and Donald (2010) proposed a consistent test of stochastic dominance when the sample sizes of comparing groups are different.

[12] That is, $H_0 : D_{01}(x) \geq 0$ for all $x \in \chi$.

$$T^*_{N,b} \equiv \begin{cases} \int_{\hat{B}} \max\left\{\sqrt{\frac{MN}{M+N}}\bar{D}^*_{01}(x), 0\right\}^2 w(x)\mathrm{d}x & \text{if } \int_{\hat{B}} w(x)\mathrm{d}x > 0 \\ \int_{\chi} \max\left\{\sqrt{\frac{MN}{M+N}}\bar{D}^*_{01}(x), 0\right\}^2 w(x)\mathrm{d}x & \text{if } \int_{\hat{B}} w(x)\mathrm{d}x = 0 \end{cases}$$

where $\bar{D}^*_{01,b}(x) = \tilde{D}^*_{01,b} - \bar{D}_{01}, \quad b = 1, \ldots, B$

In determining the size of a contact set $\hat{B} \equiv \{x \in \chi : |\bar{D}_{01}(x)| < c_K\}$, c_k[13] is a sequence that $c_k \to 0$ and $c_K\sqrt{K} \to \infty$. I propose the following simple suggestion to choose appropriate values of c:

$$\frac{1}{B}\sum_{b=1}^{B}\bar{D}_{01,b}(x) \lesssim c < \max|\bar{D}_{01,b}(x)|$$

When c is much less than the mean of $\bar{D}_{01,b}(x)$, the contact set becomes so narrow that $\hat{B} \approx 0$. Throughout this paper, the tests of stochastic dominance for each case is done with this rule of determining the value of c.

In testing joint hypothesis testing, the goal is to test whether the regulation is effective consecutively throughout the regulated years. To illustrate, when Busan implemented the regulation in 2008, this joint hypothesis enables testing the regulation effects both in 2008 and 2009 compared to 2007 (before regulation). The hypotheses are presented below.

$$H_0 = F_0(x) \leqq F_1(x) \ \& \ F_0(x) \leqq F_2(x) \text{ for all } \ x \in \chi$$
$$H_1 = F_0(x) > F_1(x) \ \& \ F_0(x) > F_2(x) \text{ for some } x \in \chi$$

In addition, this joint test is performed with different null hypothesis to obtain compatible results about the regulation effects. The test performed under the above hypothesis will be called as Test 1 and the test performed under the below will be Test 2 in the analysis.

$$H_0 : F_0(x) \geqq F_1(x) \ \& \ F_0(x) \geqq F_2(x) \text{ for all } \ x \in \chi$$

[13] K simply means $\frac{MN}{M+N}$

$$H_1 : F_0(x) < F_1(x) \;\; \& \;\; F_0(x) < F_2(x) \text{ for some } x \in \chi.$$

Despite its complicated form of test statistic for joint test, the test statistic is quite similar to previous analysis as proposed as follows.

$$T_N \equiv \max\left\{\int_{\chi} \max\left\{\sqrt{K}\bar{D}_{01}(x), 0\right\}^2 \omega(x)\mathrm{d}x, \int_{\chi} \max\left\{\sqrt{O}\bar{D}_{02}(x), 0\right\}^2 \omega(x)\mathrm{d}x\right\}$$

where $K = MN/(M+N)$ *and* $O = MQ/(M+Q)$

In case of first-order dominance, $\bar{D}_{01}(x)=\bar{F}_0-\bar{F}_1$, and $\bar{D}_{02}(x)=\bar{F}_0-\bar{F}_2$. Furthermore, M, N, and Q refers to the sample size of X_0, X_1, and X_2 respectively. Bootstrap statistic and estimating methods are almost identical to previous sections and proposed statistic. However, when using bootstrap methods, in order not to make covariance greater or less than zero, it is important to construct the test statistic with the same X_0^* to obtain $\bar{D}_{01}(x)$ and $\bar{D}_{02}(x)$.

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