

# MOTHER'S EMPLOYMENT IN EARLY CHILDHOOD AND CHILD'S EDUCATIONAL OUTCOME

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## Abstract

This paper examines the effect of maternal labor supply at the time the child is three years old on the child's test score around the age of eighteen, using Korean panel data. Considering that maternal labor in the estimation of the child's educational outcomes is endogenous, and that the effect of maternal labor on outcomes is non-linear, it is found that there is an opposite effect between high and low educational groups. Specifically, when the child's educational level is high, the outcome may be deteriorated by maternal employment, while it can be positively affected when the child's educational level is low. Maternal labor most likely results in improved financial resources, yet less time available to child's educational activities. The effect of increased monetary input seems to have a stronger effect than does the decreased time input in lower educational groups, although the opposite effect is observed in higher educational groups in Korea.

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**JEL Classification Codes:** J13, J22, D12, D13

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## 1. INTRODUCTION

There is a wealth of literature sources on the long-term effects of family environment on child's educational outcome. Several papers published in the last decade, such as those authored by Cameron and Heckman (2001), Carneiro and Heckman (2003), Cunha, Heckman, Lochner, and Masterov (2005), and Heckman and Rubinstein (2001), highlight the importance of family environment, especially in early childhood, for child's later development. Utilizing adoption data and removing parent's unobserved abilities, Sacerdote (2002) demonstrated that parents' social class is important for child's development. Baum (2003) surveyed the literature on the effect of social and educational programs on child's educational outcome. The author newly found from the estimation results that maternal marketplace work in the child's first quarter of life has detrimental effects but also contributes to the increase in household income.

Among many family backgrounds, maternal employment in early childhood is one of the most interesting topics to be examined. In many countries, a father is the primary earner and his labor hours are usually long and fixed. A mother, in contrast, decides to allocate her time to both market and home working. This means that a mother's working decision possibly decreases time available for childcare, which, in turn, discourages their development. Mother's employment can, however, raise household income and possibly encourage her child's development. Thus, a total effect of maternal employment on child's educational outcome is not decisive theoretically. The present study examines how maternal employment at the time the child is three years old affects his/her educational outcome at the age of eighteen, using Korean panel data.

Using Canadian data, Baker, Gruber, and Milligan (2008) showed that beneficial childcare services increase the rate of maternal employment, albeit at the cost of damaged relationship between parents and the children. However, Baker and Milligan (2010) did not find a significant long-term effect of maternal employment. Dustman and Schonberg (2008) pointed out that increased maternity leave in Germany raises child's educational attainments at the child's age of 18-20, although the effect is small and insignificant. Using a dataset pertaining to mothers and their children born in the U.S. between 1979 and 1988, Ruhm (2008) showed that maternal employment and her labor hours did not affect educational outcome for children in low social classes, while these factors did lower educational outcome in high social classes. Using the same data set, Bernal (2008) showed that maternal full-time employment within a year following the birth of her child discouraged the child's educational outcome. Finally, using

Japanese microdata, Tanaka and Yamamoto (2009) showed that maternal employment at the child's age of 6-12, but not at the age of 0-3, lowered the probability of that child attending high-ranking private secondary school at age of 13.<sup>1</sup>

One of the difficulties in examining the effect of maternal employment on child's educational outcome stems from the fact that this effect yields two opposite changes: maternal employment may increase monetary input, while potentially decreasing time devoted to child's education. In addition, time input itself is not simply decreased by maternal employment. Guryan et al. (2008) have shown that, although parents with higher educational attainment spend longer hours in the workplace, they also dedicate more time to childcare at home. Similarly, according to Gutierrez-Domenech (2010), Spanish parents working for longer hours allocate more time to their child's education. Finally, Hallberg and Klevmarken (2003) have shown that Swedish mothers do not decrease their childcare time even when their labor hours are increased. These results suggest that maternal employment should not discourage, but rather encourage child's educational outcome.

In this study, as Korean panel data is used to examine both child's educational outcome and the mother's employment in early childhood, it yields several contributions to this field of research. First, child's test score at age of eighteen is used as a measure of outcome. This is not just an indicator of specific events, such as dropping out, graduation, university entrance, or educational years. Moreover, the test score is not a subjective answer on relative superiority at school, as a degree of educational attainment is measured more precisely. The test score utilized in this assessment is the one used for an entrance examination of universities/colleges, which high-school students take at the age of eighteen. It should be noted here that advancement rates of high school students going to universities or colleges are extremely high in Korea. Entrance examination is a big event for many students in this country, and most of high school students take the examination anyway, which is beneficial for the analysis.

Secondly, in the estimation of child's educational outcome, endogeneity of maternal employment is accounted for. Labor force participation is decided by mothers, whose characteristics and behaviors can be related to other outcomes. If mother's unobserved ability, which is positively related to child's ability by genetics, is dropped from the regression, and if that is related to mother's employment positively (negatively), the estimates of the effect of maternal employment have upper (lower) biases. If mother's preference for child's education,

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<sup>1</sup> There are several researches on short-run effect of maternal employment on child's development. The present paper focuses on long-run effect on child's educational outcome at high-school.

which is positively related to child's educational outcome, is excluded from the regression, and if that is related to mother's employment negatively (positively), the estimates of maternal employment have lower (upper) biases. This study deals with this endogeneity, following Evans and Schwab (1995), Greene (1998), and Carrasco (2001) and using recursive bivariate probit model where decisions on maternal employment and child's test scores are estimated simultaneously.

Thirdly, the analysis considers heterogeneity or non-linearity of the effect of maternal employment over the levels of child's educational outcome carefully, checking the sign of the effects separately over the levels of educational attainment.

The main results are summarized as follows. Maternal employment at age three affects test scores at age eighteen, but this effect is opposite for high and low educational levels. Maternal employment decreases a probability that the student's test score is categorized into top ranks, i.e. higher than 10, whereas the probability that student's test score is higher than mid-low ranks (Rank 5 throughout Rank 9) increases when a mother worked at the child's age of three. Although the panel data used in the analysis do not provide sufficient information to assess the structure behind a causal effect of maternal employment on child's educational outcome, it indicates that maternal employment may decrease time available for interaction with children, which makes it less likely that children would achieve high test scores. This deteriorating effect may be offset by the positive effect of monetary inputs increased by maternal employment in low test-score groups.

This paper is composed of five main parts. The next section, Section 1.2, shows the estimation model, with the explanations provided in Section 1.3. Section 1.4 summarizes the results, and the concluding remarks are presented in the last section.

## 2. THE ESTIMATION MODEL

This study examines the effect of maternal employment at the child's age of 3 on his/her test score at the age of 18. Here,  $T_i$  is a dummy variable given the value of 1 if a child's test score is higher than a certain level, and 0 otherwise. Similarly,  $M_i$  is a dummy variable taking value of 1 if his or her mother was working when he/she was three, and 0 otherwise.  $T_i$  and  $M_i$  are determined by the latent indices such as

$$T = 1(\alpha M + x_1 \beta_1 + \varepsilon_1 > 0) \quad (1)$$

$$M = 1(x_2\beta_2 + \varepsilon_2 > 0) \quad (2)$$

Here,  $\varepsilon$  indicate error terms. If  $M$  is exogenous and two error terms are not correlated to each other, equations (1) and (2) can be estimated separately. However, as the extant literature suggests, mother's employment could be endogenous in the estimation of her child's educational outcome. Following Evans and Schwab (1995), Greene (1998) and Carrasco (2001), this analysis uses a recursive bivariate probit model for discrete choice with an endogenous dummy variable, allowing two error terms to be correlated to each other with a correlation rate of  $\rho$ :  $(\varepsilon_1, \varepsilon_2 | x_1, x_2) \sim N(0, 0, 1, 1, \rho)$ . Thus, by conducting a maximum likelihood estimation, we obtain a consistent estimator of  $\alpha$  (Heckman, 1978; Maddala, 1983; Wooldridge, 2002; Greene, 2010). Individual likelihoods are used in constructing the entire likelihood as follows:  $L_i(\alpha, \beta_1, \beta_2 | T_i, M_i, x_{1i}, x_{2i}) = P(T_i, M_i | x_{1i}, x_{2i}) = P(T_i | M_i, x_{1i}) \cdot P(M_i | x_{2i})$ , where  $P(T_i | M_i, x_{1i}) = P(T_i = 1 | M_i = 1, x_{1i}) = P(\alpha + x_{1i}\beta_1 + \varepsilon_{1i} > 0 | \varepsilon_{2i} > -x_{2i}\beta_2) = \int_{-x_{2i}\beta_2}^{\infty} \Phi\left(\frac{\alpha + x_{1i}\beta_1 + \rho\varepsilon_{2i}}{\sqrt{1-\rho^2}}\right) \frac{\phi(\varepsilon_{2i})}{\Phi(x_{2i}\beta_2)} d\varepsilon_{2i}$ .

The explanatory variables  $x_{1i}$  include both parental, child's characteristics, and maternal employment,  $M_i$ , as well as household economic condition and parental educational attainment. The explanatory variables for maternal employment,  $x_{2i}$ , must include an additional exogenous variable other than  $x_{1i}$ . Thus, the analysis is based on the female labor force participation rates in the country around the time when the child was born, and/or the regional average employment rates in the sample of mothers (excluding the child's mother) when the child was three years old. These two variables are considered to affect maternal employment through environmental effect or peer effect of female labor supply at that time, but not to affect child's educational outcome at the age of 18.

The main null hypothesis is that  $\alpha$  is zero, i.e. there is no effect of maternal employment in the early childhood on the later educational outcome.<sup>2</sup> Note that we cannot predict the sign of the coefficient on maternal employment, as it can encourage her child's educational outcome ( $\alpha > 0$ ), as well as hinder it ( $\alpha < 0$ ). Even after controlling for household's economic conditions and the parent's education, maternal employment that generates additional funds for child's education might be beneficial for child's development. In contrast, maternal employment resulting in less child care time and/or more unhealthy behaviors may discourage child's

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<sup>2</sup> We focus on the sign of the coefficient on maternal employment, but we calculate a marginal effect as  $E(T_i | x_{1i}, x_{2i}) = P(M_i = 1)E(T_i | M_i = 1, x_{1i}, x_{2i}) + P(M_i = 0)E(T_i | M_i = 0, x_{1i}, x_{2i})$  when needed.

development. Since it is not possible to observe time and monetary allocation within a household at the child's age of 3, the present estimation cannot analyze these points explicitly. This will be discussed later, when the results are explained.

It should be noted here that the test score raw data is ranked into twelve levels. Hence, the above simultaneous equations Eq. (1) and Eq. (2) are estimated repeatedly for each rank of test scores, examining whether or not a child's test score is categorized into higher than (or equal to) each rank. That is, a probability that a child's test score is higher than or equal to the rank of five (which is about bottom 10% of test-score distribution), six, seven, . . . , and eleven (which is about top 10% of test-score distribution) is estimated, and the null of  $\alpha$  is tested in each estimation, respectively. The reason for not using the original continuous test ranks is that taking nonlinearity of maternal-employment effect on child's outcome into consideration must be important. Similarly, the ordered information on test scores is not used in the analysis because additional estimation of the thresholds is required, and the results are sometimes unstable when the number of the samples in the rank is limited. In fact, the ordered test scores of Eq. (1) are estimated using a dummy endogenous maternal employment of Eq. (2) by GHK simulator. However, the results are not robust, as the estimates are changeable depending on the assumption used for the calculation of the simulated maximum likelihood, such as initial points, the number of repetitions, whether Random draws or Halton draws are used, and so on.

### 3. DATA

In this part of the study the data is sourced from *Korean Labor and Income Panel Study (KLIPS)*, 1998-2008, compiled by Korean Labor Institute. KLIPS is a large micro-data set comprising individual data on individuals aged 15 and older (about 120,000 individuals for eleven waves), and household data pertaining to the household head and spouse (about 5,000 in total). In 2006, the additional survey was conducted on the young people (aged from 15 to 35 years old, 4,389 individuals). The questions included focused on mother's employment status at the time the child was three years old, and household characteristics at the time they were grown up. The responses to this additional survey are used for the present analysis.

The main dependent variable is a test score attained at the university entrance examination, which is provided by the respondents aged 30 or younger in 2002 individual data. This is called

College Scholastic Ability Test (here after referred as CSAT: *de-hak-su-hak-nung-ryok-si-hum* in Korean). University entrance examination takes place once a year, on the same day, which allows for controlling for unobserved environment related to entrance examination. Test scores are grouped into categories, from one to twelve, and each consists of different ranges, depending on the type of CSAT the respondent took: AAT (total score of 340; year 1988-1993), CSAT\_1 (200; year 1994-1996), and CSAT\_2 (400; year 1997-2001). The differences in this examination type in CSAT are controlled for in the subsequent analysis by using dummy variables. Year dummies indicating when the respondent took examination are also used, since the level of examinations has changed over the years.

The most important explanatory variable is a dummy variable on mother's employment at the time the child was three years old. This is a retrospective answer by the respondents. Relative household economic conditions, compared to the other households, at the time the child is fourteen, are used as control variables, ranging from 1 (poor) to 4 (wealthy). This is provided as a subjective answer by the respondents. Although parent's income at the time the child is aged eighteen is also provided in the survey directly, this information is not included in the analysis. This is because many answers are missing, and because a problem of endogeneity of household economic condition in the estimation of child's outcome could be more serious when the time points when the two variables are measured are close. Another control variable is parents' education. There is ample literature on the relationship between parents' education and that of their child. In the present analysis, parents' education is included as a control for ability and/or household lifetime wealth, although parents' education may not affect test scores directly, unlike child's educational attainment, measured in years of schooling.

The other control variables are family background, such as whether or not a child lived with parents at the age of 14, residential area at the age of 14, and child's characteristics (such as gender, number of siblings, and whether or not he/she is the eldest child). The variables added for the estimation of maternal employment at the time the child is three years old are (i) female labor force participation rates in the entire country at the time the child is three years old, and (ii) average mother's employment rates in the sample in the area where a child was born, during the first few years of child's life. These variables partly measure the environmental effect or peer effect of female labor supply, whereby the coefficients on these two variables can be positive in the estimation of maternal employment. The definitions of the variables and their descriptive statistics are summarized in Table 1.

## 4. RESULTS

### 4.1 Main Results

First, the results are presented without considering the endogeneity of maternal labor and estimating the child's educational outcome, Eq. (2), by Probit model, for reference. Table 2 reports the estimation results, separately in each column, on the probability that test score is higher than or equal to each test-score rank. For example, in column (1) the result on whether or not test score is higher than or equal to Rank 12 is given, while column (8) shows whether or not test score is higher than or equal to Rank 5. Positive coefficients indicate that the variables increase the probability that the student's test score is categorized into higher ranks. Note that thresholds of test-score ranks are bottom 9.1% of total test-score distribution for Rank 5, bottom 17.57% for Rank 6, bottom 29.63% for Rank 7, bottom 46.03% for Rank 8, bottom 60.21% (top 39.79%) for Rank 9, bottom 72.80% (top 27.20%) for Rank 10, bottom 83.49% (top 16.51%) for Rank 11, and bottom 90% (top 10%) for Rank 12.

Column (1) shows a negative coefficient on maternal employment for Rank 12 or higher. The negative effects are also found in column (2) for Rank 11 or higher, in column (3) for Rank 10 or higher, in column (4) for Rank 9 or higher, and column (5) for Rank 8 or higher. Here, the coefficient for Rank 9 or higher is significant at 10% significance level. Maternal employment decreases the probability that a child's test score is higher than or equal to Rank 9 – an existence of the discouraging effect of maternal employment at the child's age of three on the child's educational outcome at the age of eighteen. In contrast, the coefficients become positive for thresholds of Rank 7 (column (6)), 6 (column (7)) and 5 (column (8)), although none are significant at 10% significance level. These results suggest that the effects of maternal employment on the child's educational outcome are potentially heterogeneous, depending on the child's educational attainment level, whereby it could be negative for the child with a higher educational level, while it could be positive for the child with a lower educational level. These results also suggest that the effects could be ambiguous due to the fact that maternal employment is endogenous in the estimation of child's outcome. Unobserved characteristics that compound the problem of endogeneity could be related to maternal employment both positively and negatively, which produces unclear results.

The aforementioned effect of maternal employment on the child's educational outcome is obtained after controlling for the household's, parents' and child's characteristics. Mother's



educational level and household relative income level have a positive effect on child's test rank, for which the coefficients are significant at 10% significance level in some specifications. The eldest child is in higher rank, for which the coefficient is significant at 5% level in most ranks. All of these findings are predicted by the hypotheses. Many other specifications of the estimation were then tested. For example, relative school-achievement at middle school was added to the model, which is a subjective answer by the respondent, indicating how well he/she did at middle school compared to the other students. The main results have hardly changed by this modification.

Although endogeneity is not taken into account in Table 2, the results point out a striking symmetry effect of maternal employment on the child's educational outcome between high and low educational outcomes. To confirm this point, quantile regression was conducted, using 12 values of raw data on test scores, which yielded the same result: the effect of maternal employment is negative in the top 25% of the test-rank distribution which is roughly above Rank 8, while it is positive in the bottom 25% (see Appendix 1 for the results). In addition, an ordered probit model was estimated without consideration of endogeneity, which indicated that none of the estimates are statistically significant. However, the signs of marginal effects again suggest that negative effects exist in Rank 8 and above, while positive effects exist in Ranks 5, 6, and 7 (see Appendix 2 for the results). This suggests that heterogeneity in the effect of maternal employment can be found, regardless of estimation methods. Panel A of Table 3 shows the results of the estimation of Eq. (2) as well as Eq. (1) simultaneously by bivariate probit model, adding exclusion variable for mother's employment decision, measured as female labor force participation rates in the entire country around a child's age of three. The coefficients on maternal employment are again negative in the high test-score groups, but are limited to the thresholds of Rank 10 and 11. Both coefficients are significant at 1% significance level. These findings imply that the probability of scoring higher than or equal to Rank 10 decreases when a mother worked at the child's age of three. In sharp contrast, the coefficients on maternal employment are positive in lower test-score groups. In particular, when the thresholds are set at Rank 5, 6, and 7, the coefficients on maternal employment are significant at 1% significance level. In other words, maternal employment at age three increases the probability that a child's test score would be higher than or equal to Rank 5, 6, or 7.

Similar results are found in Panel B where mother's employment rates at the time of child's birth, averaged in the area where a child was born, are added as an exclusion variable for

the estimation of maternal employment. The results are almost unchanged, with the exception of the coefficient on maternal employment in Rank 10, which is not insignificant at 10% level.

Thus, maternal employment affects child's test scores positively for children in low educational levels—specifically in Rank 5-7 (bottom 9-46% in the test score distribution), and negatively for children in high educational levels—specifically in Rank 10-11 (top 16-27%). Maternal employment in early childhood possibly hinders the child's educational outcome; however, this effect is limited to high test-score groups of 16%. In contrast, it encourages the child's educational outcome in lower test-score groups of bottom 46%.<sup>3</sup>

Comparing the results presented in Table 3 to those in Table 2, it is evident that the directions of the endogeneity biases are different between high and low test-score groups. Roughly speaking, in the groups above Rank 10, the coefficients have upper bias in Table 2, where the coefficients were negative but small in the ranks higher than 11 in Table 2, which turned to be larger and significantly negative in Table 3. In contrast, in the groups below the thresholds of Rank 7, the coefficients have lower bias in Table 2, whereby the coefficients were positive but small in Rank 5, 6, and 7 in Table 2, but were larger and significantly positive in Table 3.

There are some possible explanations of these lower and upper biases related to the effect of maternal employment in lower and higher test-score classes. As one explanation, in the groups of children with higher educational levels, working mothers could have higher unobserved abilities, which are related to the children's higher abilities and test scores. As another explanation, in these groups, working mothers have stronger preferences for their children's educational outcomes, which are related to the children's higher test scores. In these cases, if endogeneity of maternal employment is not taken into account, true negative effects can be crowded out. The opposite logic can be applied to the groups of children with lower educational levels. Working mothers in these groups could have lower unobserved abilities or

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<sup>3</sup> We also conducted Instrumental Variable estimation, treating test-score ranks as continuous variables and instrumenting female labor force participation rates and/or mother's employment rates of the child's birth year and place for maternal employment for maternal employment at the time the child was aged three. The results indicate that the coefficients on maternal employment in the structural equation (the second stage equation) are insignificant. This finding may indicate that the effect of maternal employment would cease when its endogeneity is taken into account. However, the effect of maternal employment could not be observed, as we did not account for nonlinear effects of maternal employment, especially since the effects could be opposite between high and low test-score groups. These results suggest that endogeneity and nonlinearity of maternal employment should be considered at the same time (see Appendix Table 1-3 for the results of IV estimation).

could have lower preferences for children's education, which crowds out true positive effects. As will be examined in a discussion section, these explanations may fit to the sample used in this study, although this is one of the possible explanations.

#### 4.2 Discussion

Why does maternal employment hinder the child's educational outcomes in high educational groups and encourage them in low educational groups? Since KLIPS does not provide sufficient information to examine causal factors behind this finding explicitly, the descriptive statistics are employed here.

Table 4 reports the differential in parental characteristics and behaviors, including two measures of time and monetary inputs by parents, separately for high and low test-rank groups. More specifically, the thresholds of Rank 7 and Rank 10 are used, for which statistically significant effects of maternal employment on child's educational outcome in Table 3–Panel A were found. First row shows that the differentials in maternal employment at the child's age of three are small among test-score groups: about 40% in the groups below Rank 7, 42% in the group between Rank 7 and 9, and 33% in the group higher than Rank 10. Maternal employment rates are somewhat small in the highest test-rank groups, i.e. Rank 10 and above, which does not contradict the usual finding in the country, whereby, in Korea like in some other Asian countries, most women stop working when they get married.

According to the middle rows of Table 4, either father or mother in higher test-rank groups has higher educational attainment, and household economic status at child's age 14 in higher ranks is also higher, although the latter is not markedly different among test ranks. In addition, fathers in higher test ranks are more likely to work as “professionals”, “technicians and associate professionals”, and “clerks”, and less likely to be “skilled agricultural, forestry and fishery workers”, compared to fathers in lower test-rank groups. These statistics suggest that types of maternal employment might be different between high and low test ranks. Working mothers, in low test ranks, might be low skilled workers, say working for family business helping husband's agricultural works or working as non-regular workers. Working mothers in high test ranks, on the other hand, might be highly skilled workers, and are more likely to work full-time.

This difference in types of maternal employment can affect time and monetary inputs into child's education. KLIPS included a question inquiring much time a respondent spent with

his/her parent(s) to talk about (1) school life, (2) politics or social issues, (3) books, TV or movies, (4) his/her own worries, (5) having dinner together, and (6) having leisure activities together. Each one of six items is answered by offering a score ranging from 1 to 5, reflecting the frequencies. The average score was used as a measure of child's interaction with parents, i.e. a degree of parental time input on child's education. KLIPS also asks whether a respondent went to private schools or institutions for music, sports, education (mathematics, English etc.) before entering elementary school. This response was used as a measure of monetary input into child's education. Since child's ability is unobserved usually in early childhood, this is good to measure pure investment by parents.

The bottom rows of Table 4 present these time and monetary inputs. When high and low test-rank groups at the threshold of Rank 10 are compared, children in high test ranks have a higher degree of interaction with parents at age fourteen as well as more extracurricular activities before starting elementary school. The similar tendency is also observed when the groups at the threshold of Rank 7 are compared. However, the difference in extracurricular activities before school entry is rather small among test ranks. Children in the low test ranks, i.e. those below Rank 7, received fewer time and monetary inputs by the parents, even though the difference in monetary input into education by parents is not so great compared to children in test ranks above 7.

It should be reiterated that the main finding in Table 3 was that maternal employment affect child's test score negatively in high score groups and positively in low score groups. According to the difference in time and monetary inputs discussed in the last paragraph, the child's educational outcome might not be lowered by an increase in monetary input complementing time input by maternal employment, while the child's educational outcome might be lowered by a decrease in time input caused by maternal employment. Note that, when the endogeneity of maternal employment is not accounted for, Table 3 indicated that the effect is biased upward in high score groups and downward in low score groups. Thus, it is evident that time and monetary inputs can be strongly related to parental preferences for child's education. The existence of this preference, which is unobserved and excluded from the error term in the estimation of Eq. (1), would make the estimates of the effect of maternal employment biased upward in high test-score groups, since the parents had higher preference for child's education, while it would make the estimates biased downward in low test-score groups since the parents had lower preferences for child's education.

Next, the predicted value of the percentage of higher test ranks when the mothers were employed when child was aged three are calculated as  $P(T_i = 1|M_i = 1)$ , based on the results obtained in Panel A of Table 3. Table 5 shows the average predicted value in the groups with high and low interaction with parents, as well as with more and less extracurricular activities, separately in high and low test-rank groups. The percentage of test ranks becoming higher than or equal to 10 would decrease significantly, as interaction with parents becomes less frequent, regardless of the amount of extracurricular activities (it declines from 72.7% to 55.0% when the child received extracurricular activities, and from 66.6% to 41.6% when the child did not receive extracurricular activities). This tendency changes when we the group is segregated at test-rank 5. Although, as before, the percentage of higher test scores would decline as interaction with parents becomes less frequent, the reduction is not so marked (it decreases from 76% to 68.1% when the child received extracurricular activities and from 75.6% to 67.2% when the child did not receive extracurricular activities).

Holding a degree of interaction with parents constant, the percentage of higher test ranks would decline as extracurricular activities become less frequent. This effect was observed in both the threshold of Rank 10 or in that of Rank 5. However, once again, when the groups are split at Rank 5, the degree of decline of extracurricular activities is not so pronounced.

Maternal employment affects child's educational outcome, decreasing time input and increasing monetary input. When maternal employment changes time and monetary inputs differently, it also affects the child's educational outcome differently. In Korea, maternal employment in the early childhood discourages child's educational outcome in high educational level groups, possibly due to a more pronounced negative effect of less time input, while it encourages child's educational outcome in low educational level groups, possibly due to a greater positive effect of additional monetary input. This may suggest that time is important for child's development once a certain level of education is acquired. It is noted that, however, the background behavioral differences in time and monetary inputs are not explicitly taken into account in the estimation model presented here. To clarify the causal effect of maternal employment, further examination of time and money allocation within a family is necessary.

## 5. CONCLUSION

This study presented the findings pertaining to the way in which maternal employment at the time the child is aged three affects the child's test score at the age of eighteen, using unique Korean panel data. There are two important features to be considered: endogeneity of maternal employment in the estimation of child's outcome, and non-linearity of the effect of maternal employment. If mother's unobserved ability, which is positively related to child's ability by genetics, is excluded from the regression, and if that is related to mother's employment positively (negatively), the estimates of the effect of maternal employment have upper (lower) bias. Similarly, if mother's preference for child's education, which is positively related to child's educational outcome, is dropped from the regression, and if that is related to mother's employment negatively (positively), the estimates of maternal employment have lower (upper) bias. Here the decisions on test scores and maternal employment are considered simultaneously. At the same time, non-linearity of the effect is assessed carefully, checking the sign of the effects separately in each equation.

The findings presented above imply that maternal employment at the time the child is aged three affects test scores at the age eighteen asymmetrically. It raises the test scores for children at low educational levels, whereas it lowers the test scores for children at high educational levels. This result is obtained after controlling for household economic conditions and parents' educational attainments as well as endogeneity of maternal employment.

However, it should be noted that the analysis did not include the structure behind a causal effect of maternal employment on child's educational outcome. As possible explanations, however, maternal employment may decrease interaction time with children, which reduces the likelihood of attaining high test scores for children in high test-rank groups. This negative effect may be offset by the positive effect of monetary input increased by maternal employment in low test-rank groups.

These results suggest that we should examine the effect of maternal employment on child's outcome carefully: small or no effects would be found if we did not consider nonlinearity and endogeneity of maternal employment carefully. Future studies should focus on analyzing the background of the causality from maternal employment to child's outcome, including parents' time and monetary allocation within a family.

Table 1. Descriptive Statistics

## 1-1. Dependent variable and family background indicators

Name of Variable	Definition of variable	Mean	S.D.	Source
<b>Educational Outcomes</b>				
Test score attained at the university entrance examination	Test score of "College Scholastic Ability Test" (CSAT) (1~12 Ranks)	7.856	2.420	2002 Individual survey
<b>Family background</b>				
Maternal Employment at child's age 3 (=1)	Whether mother worked at age 3 (=1)	0.390	0.488	2006 Additional survey
Female labor force participation rate at child's age 3	Labor force participation rate=(Labor force/population aged 15 or more)*100 The labor force is the total # of workers, including the employed and unemployed. To use "Female labor force participation rate by age", we first calculated mother's age at child's age 3 and used female force participation rate in the 1970-1985 period when the respondent (children) was 3 years old	38.062	7.564	National Statistical Office, 'Economically Active Population Survey' 1998~2006 Individual surveys
Mother's employment rate of the child's birth place	Average probability of mother's employment by area where the child (respondent) was born	0.378	0.108	2006 Additional survey
Mother's educational attainment	The level of mother's educational attainment at the time of 2006 survey (1~7)	3.028	1.100	1998~2006 Individual surveys
Father's educational attainment	The level of father's educational attainment at the time of 2006 survey (1~7)	3.739	1.330	1998~2006 Individual surveys
Living with parents at age 14 (=1)	Whether the respondent lived apart from both parents at age 14 (because of parents' divorce, separation by death, one parent's employment in other areas, or etc.)	0.025	0.157	2006 Additional survey
Household economic status at age 14	Household economic status when the respondent was 14 years old (4 dummies: 1 for lowest to 4 highest)	0.049 0.230 0.568 0.154	0.217 0.421 0.496 0.361	1998~2006 Individual surveys

## 1-2. Child's characteristics

<b>Child's characteristics</b>				
First child (=1)	First child (=1)	0.401	0.491	2003~2006 Individual surveys
Number of siblings	Number of brother(s) and sister(s)	1.885	1.093	2003~2006 Individual surveys
Residential area at age 14	Where the respondent lived at age 14 3 dummies constructed from 17 administrative regions of South Korea: 1) Seould (Base group) 2) 6 Metropolitan cities 3) 9 Provinces and Jeju island	0.211	0.408	1998~2006 Individual surveys
Sex	male (=1)	0.370	0.483	1998~2006 Individual surveys
Kinds of university entrance exam	Kinds of university entrance exam held in the 1988-2001 period : 3 dummies 1) AAT (Academic Achievement Test): 1988-1993 (Base) 2) CSAT_1 (College scholastic test 1): 1994-1996 2) CSAT_2 (College scholastic test 2): 1997-2001	0.252	0.435	2002 Individual survey
Degree of interaction with parents at age 14	How much the respondent spend time with their parent(s) to talk about (i) school life (ii) politics/social issues (iii) books/TV/movies (iv) one's own worries (v) to have dinner together (vi) to have leisure activities, etc together  Average of 6 categories (scale of each category is a 1-5 raiting)	16.788	5.725	2006 Additional survey
Private education before school entry	Whether the respondent went to priivate schools/institutions for music, sports, education related subjects (mathematics, English, and etc) before entering elementary school (compulsory education)	0.276	0.447	2006 Additional survey



Table 2. Estimation Results (without taking into consideration the endogeneity of maternal employment)

Dependent Variable: A binary indicator that equals one if test score is higher than the given rank (12 ~5) and zero otherwise Estimating Equation (1) : Probit model	Higher than 12 Higher than 11 Higher than 10 Higher than 9 Higher than 8 Higher than 7 Higher than 6 Higher than 5							
	<i>Variable</i>							
Maternal employment at child's age 3	-0.0443 (0.159)	-0.1430 (0.128)	-0.1244 (0.111)	-0.1961* (0.104)	-0.0845 (0.102)	0.0552 (0.109)	0.0048 (0.123)	0.1527 (0.151)
Father's educational attainment	0.0742 (0.081)	0.0823 (0.066)	0.1004* (0.058)	0.0695 (0.055)	0.1431*** (0.055)	0.1488** (0.060)	0.0473 (0.069)	0.0674 (0.085)
Mother's educational attainment	0.2362** (0.100)	0.1635** (0.082)	0.1487** (0.072)	0.1569** (0.070)	0.0957 (0.069)	0.0796 (0.076)	0.1689* (0.089)	0.2880*** (0.110)
Household economic status at age 14 (2)	4.0533 (165.122)	0.9187** (0.453)	0.5492* (0.293)	0.3731 (0.246)	0.2987 (0.237)	0.3247 (0.243)	0.4804* (0.261)	0.5665* (0.297)
Household economic status at age 14 (3)	3.8147 (165.122)	0.6283 (0.445)	0.2552 (0.285)	-0.0112 (0.237)	-0.0035 (0.227)	0.1840 (0.231)	0.3939 (0.247)	0.4114 (0.277)
Household economic status at age 14 (4)	3.9965 (165.122)	0.7213 (0.463)	0.2543 (0.310)	0.2189 (0.263)	0.1477 (0.255)	0.3316 (0.263)	0.5289* (0.288)	0.3551 (0.323)
Living with parents at age 14 (=1)	+	+	-0.6425 (0.409)	-0.2408 (0.333)	-0.0800 (0.316)	-0.0093 (0.334)	-0.1071 (0.367)	-0.0745 (0.424)
First child (=1)	0.0127 (0.162)	0.0966 (0.130)	0.2395** (0.114)	0.1883* (0.109)	0.1337 (0.108)	0.2288** (0.116)	0.3002** (0.135)	-0.0186 (0.161)
Number of siblings	-0.0129 (0.088)	-0.0044 (0.068)	0.0137 (0.057)	-0.0043 (0.053)	-0.0243 (0.051)	-0.0399 (0.054)	0.0012 (0.061)	-0.0227 (0.073)
Male (=1)	0.1599 (0.162)	-0.0494 (0.133)	-0.0922 (0.116)	0.0531 (0.108)	0.0267 (0.107)	-0.1710 (0.114)	-0.1627 (0.130)	-0.0810 (0.158)
Residential Area at age 14 (6 metropolitan cities)	0.2488 (0.190)	0.0652 (0.160)	-0.1618 (0.142)	-0.1630 (0.138)	-0.2235 (0.141)	-0.3408** (0.156)	-0.4611** (0.197)	-0.1653 (0.240)
Residential Area at age 14 (9 provinces and Jeju)	-0.2234 (0.210)	-0.1016 (0.165)	-0.3019** (0.144)	-0.2796** (0.138)	-0.2467* (0.140)	-0.3362** (0.156)	-0.5810*** (0.194)	-0.3572 (0.235)
CSAT_1	0.2842 (0.219)	0.3852** (0.173)	-0.0781 (0.146)	-0.1609 (0.136)	-0.1862 (0.135)	-0.2578* (0.148)	-0.2018 (0.174)	-0.2684 (0.215)
CSAT_2	0.1570 (0.217)	0.2007 (0.171)	-0.1496 (0.141)	-0.2989** (0.132)	-0.4223*** (0.131)	-0.6780*** (0.143)	-0.6689*** (0.165)	-0.6441*** (0.206)
<i>Marginal Effect</i>								
Maternal employment at child's age 3	-0.006 (0.022)	-0.033 (0.029)	-0.038 (0.034)	-0.0706* (0.037)	-0.031 (0.038)	0.018 (0.035)	0.001 (0.028)	0.022 (0.021)
Constants	-6.5586 (165.123)	-2.6729*** (0.548)	-1.5235*** (0.392)	-0.7520** (0.351)	-0.3542 (0.346)	0.2459 (0.371)	0.6889 (0.420)	0.5911 (0.500)
Observations	692	692	710	710	710	710	710	710

Table 3-Panel A. Estimation Results (1) (The endogeneity of maternal employment was taken into consideration)

Dependent Variable: A binary indicator that equals one if test score is higher than the given rank (12 ~5) and zero otherwise Estimating simultaneous equations (1) and (2) : Bivariate probit model	Higher than 11	Higher than 10	Higher than 9	Higher than 8	Higher than 7	Higher than 6	Higher than 5							
Maternal employment at child's age 3	-1.4954*** (0.201)	-1.5754*** (0.083)	0.0782 (2.422)	1.0287 (0.744)	1.4568*** (0.081)	1.4702*** (0.219)	1.1544*** (0.261)							
Female Labor Force Participation Rate (By age)	0.0197*** (0.006)	0.0153*** (0.006)	0.0173** (0.009)	0.0174** (0.008)	0.0212** (0.009)	0.0191*** (0.007)	0.0199*** (0.007)							
Father's educational attainment	-0.0619 (0.073)	-0.2199*** (0.061)	-0.0484 (0.068)	-0.2173*** (0.175)	0.1271 (0.070)	-0.2104*** (0.063)	0.2509*** (0.065)	-0.2092*** (0.128)	0.2490* (0.230)	-0.2339 (0.066)	0.2409*** (0.069)	-0.2085*** (0.099)	0.2592*** (0.067)	-0.2103*** (0.067)
Mother's educational attainment	0.1668** (0.083)	0.0857 (0.083)	0.1184 (0.075)	0.0800 (0.084)	0.1237 (0.110)	0.0802 (0.085)	0.0039 (0.084)	0.0827 (0.085)	-0.0068 (0.110)	0.1140 (0.261)	0.0206 (0.096)	0.0713 (0.086)	0.2436* (0.134)	0.0771 (0.084)
Household economic status at age 14 (2)	0.5885 (0.365)	0.2011 (0.284)	0.4250* (0.241)	0.1945 (0.274)	0.2746 (0.345)	0.1523 (0.284)	0.1044 (0.274)	0.1528 (0.262)	0.0365 (0.229)	0.0989 (0.246)	0.1827 (0.296)	0.1607 (0.268)	0.7044** (0.352)	0.1692 (0.280)
Household economic status at age 14 (3)	0.4550 (0.334)	0.2782 (0.268)	0.3123 (0.232)	0.3025 (0.270)	-0.0720 (0.362)	0.2433 (0.295)	-0.1275 (0.263)	0.2352 (0.257)	-0.1066 (0.215)	0.1816 (0.242)	0.0047 (0.261)	0.2735 (0.265)	0.3098 (0.333)	0.2636 (0.276)
Household economic status at age 14 (4)	0.6033* (0.357)	0.3300 (0.300)	0.4363* (0.262)	0.2597 (0.302)	0.1870 (0.445)	0.2881 (0.311)	0.0299 (0.328)	0.2735 (0.295)	-0.0512 (0.405)	0.1305 (0.665)	0.0267 (0.327)	0.2723 (0.305)	0.3985 (0.380)	0.3013 (0.310)
Living with parents at age 14 (=1)	-5.1576*** (0.215)	-0.2416 (0.417)	-0.2940 (0.317)	-0.2604 (0.344)	-0.0440 (0.439)	-0.2635 (0.519)	0.3151 (0.355)	-0.2547 (0.425)	0.1811 (0.320)	-0.1749 (0.423)	-0.0969 (0.335)	-0.1861 (0.413)	-0.1486 (0.512)	-0.2610 (0.446)
First child (=1)	0.1111 (0.120)	0.0683 (0.124)	0.2244** (0.110)	0.0211 (0.122)	0.2528* (0.135)	0.0602 (0.129)	0.1021 (0.126)	0.0637 (0.125)	0.1351 (0.169)	0.0771 (0.238)	0.2037 (0.136)	0.0932 (0.124)	0.0029 (0.172)	0.0730 (0.126)
Number of siblings	0.0336 (0.068)	0.0563 (0.068)	0.0486 (0.063)	0.0708 (0.068)	0.0064 (0.088)	0.0504 (0.068)	-0.0706 (0.063)	0.0522 (0.068)	-0.0583 (0.061)	0.0509 (0.068)	-0.0224 (0.065)	0.0588 (0.067)	0.0242 (0.088)	0.0490 (0.067)
Male (=1)	0.0591 (0.122)	0.1259 (0.127)	-0.0020 (0.115)	0.1869 (0.127)	-0.0199 (0.184)	0.1403 (0.128)	-0.1575 (0.120)	0.1437 (0.126)	-0.2423 (0.155)	0.1856 (0.199)	-0.1946 (0.131)	0.1507 (0.130)	-0.2511 (0.175)	0.1400 (0.128)
Residential Area at age 14 (6 metropolitan cities)	-0.0607 (0.182)	-0.3340** (0.162)	-0.3035** (0.137)	-0.2908* (0.153)	-0.0069 (0.351)	-0.3454** (0.168)	0.0445 (0.205)	-0.3406** (0.164)	0.0608 (0.182)	-0.3728** (0.176)	0.0205 (0.210)	-0.3609** (0.161)	0.0538 (0.254)	-0.3529** (0.163)
Residential Area at age 14 (9 provinces and Jeju)	0.1650 (0.160)	0.1016 (0.155)	-0.0317 (0.140)	0.0880 (0.153)	-0.1041 (0.163)	0.0921 (0.172)	-0.0935 (0.149)	0.1029 (0.160)	-0.1562 (0.146)	0.0870 (0.247)	-0.3244* (0.190)	0.1102 (0.157)	-0.3225 (0.231)	0.0858 (0.157)
CSAT_1	0.3607* (0.217)	-0.0485 (0.173)	-0.0631 (0.156)	-0.0042 (0.171)	-0.0399 (0.183)	-0.0472 (0.173)	-0.0476 (0.173)	-0.0425 (0.172)	-0.0671 (0.301)	-0.0044 (0.370)	-0.1395 (0.190)	-0.0390 (0.169)	-0.6528** (0.280)	-0.0465 (0.172)
CSAT_2	0.2470 (0.189)	-0.0490 (0.167)	-0.1187 (0.149)	0.0314 (0.168)	-0.2046 (0.165)	-0.0386 (0.166)	-0.3367* (0.197)	-0.0326 (0.167)	-0.3955 (0.312)	-0.0007 (0.326)	-0.4389* (0.249)	-0.0356 (0.168)	-1.0311*** (0.291)	-0.0448 (0.167)
<i>Marginal Effect</i>														
Maternal employment at child's age 3	-0.7401	-0.7756	0.0291	0.4220	0.7481	0.7897	0.2748							
Constants	-1.3531* (0.735)	-0.8375* (0.461)	-0.3030 (0.364)	-0.7466 (0.458)	-1.1045 (1.027)	-0.7123 (0.509)	-0.8157* (0.444)	-0.7359 (0.490)	-0.5772* (0.349)	-0.8503* (0.499)	-0.4015 (0.413)	-0.8174* (0.455)	-0.1862 (0.591)	-0.8160* (0.488)
Observations	533	533	533	533	533	533	533	533	533	533	533	533	533	
rho: correlation between errors	1.5072** (0.702)	11.6910 (19.372)	-0.1731 (1.513)	-0.8217 (0.932)	-2.9949 (21.604)	-1.7466 (1.223)	-0.6833*** (0.223)							

Note: Additional regressions were conducted separately by gender for the robustness check. There are no marked differences between female and male students, except that the discouraging effect is only observed among male students. The positive effect of maternal employment on the probability that the student's test score is higher than the mid-low ranks (from 9 to 5) is observed, regardless of gender. However, caution is needed in interpreting the results, because the sample was very small and was not evenly distributed by gender (males: N = 192, females: N = 341).

Table 3-Panel B. Estimation Results (2) (The endogeneity of maternal employment is taken into consideration)

Dependent Variable: A binary indicator that equals one if test score is higher than the given rank (12 ~5) and zero otherwise Estimating simultaneous equations (1) and (2) : Bivariate probit model	Higher than 12	Higher than 11	Higher than 10	Higher than 9	Higher than 8	Higher than 7	Higher than 6	Higher than 5								
Maternal employment at child's age 3	-0.0322 (1.961)	-1.4935*** (0.264)	-0.1771 (1.455)	0.4082 (1.053)	0.6591 (0.828)	1.4584*** (0.081)	1.3974*** (0.233)	1.0223*** (0.353)								
Female Labor Force Participation Rate (By age)	0.0169* (0.009)	0.0198*** (0.007)	0.0170* (0.009)	0.0162* (0.009)	0.0182** (0.008)	0.0217*** (0.005)	0.0194*** (0.006)	0.0192** (0.008)								
Mother's employment rate of the child's birth place	1.6639** (0.751)	1.1984** (0.569)	1.6581** (0.777)	1.6790** (0.679)	1.5674** (0.756)	1.1611*** (0.418)	1.3414** (0.644)	1.5731** (0.686)								
Father's educational attainment	0.0176 (0.171)	-0.2059*** (0.068)	-0.0597 (0.078)	-0.2139*** (0.067)	0.1176 (0.127)	-0.2058*** (0.068)	0.1470 (0.090)	-0.2016*** (0.067)	0.2383*** (0.076)	-0.2029*** (0.066)	0.2538*** (0.060)	-0.2159*** (0.066)	0.2411*** (0.069)	-0.2073*** (0.068)	0.2573** (0.102)	-0.2050*** (0.067)
Mother's educational attainment	0.3173** (0.135)	0.0667 (0.086)	0.1691** (0.085)	0.0715 (0.083)	0.1253 (0.091)	0.0666 (0.086)	0.1112 (0.091)	0.0675 (0.085)	0.0193 (0.087)	0.0676 (0.085)	-0.0127 (0.076)	0.0867 (0.085)	0.0339 (0.095)	0.0634 (0.085)	0.2591* (0.138)	0.0649 (0.085)
Household economic status at age 14 (2)	4.5697*** (0.327)	0.1568 (0.280)	0.5886 (0.392)	0.2078 (0.297)	0.4632 (0.316)	0.1558 (0.281)	0.2443 (0.291)	0.1327 (0.274)	0.1528 (0.280)	0.1416 (0.270)	0.0353 (0.224)	0.0923 (0.244)	0.2255 (0.286)	0.1617 (0.266)	0.7478** (0.365)	0.1653 (0.279)
Household economic status at age 14 (3)	4.2330*** (0.371)	0.2516 (0.271)	0.4570 (0.344)	0.2812 (0.275)	0.1847 (0.328)	0.2512 (0.277)	-0.1015 (0.280)	0.2191 (0.272)	-0.0852 (0.280)	0.2299 (0.265)	-0.1092 (0.218)	0.1780 (0.240)	0.0296 (0.261)	0.2624 (0.265)	0.3382 (0.340)	0.2589 (0.275)
Household economic status at age 14 (4)	4.5689*** (0.448)	0.3203 (0.305)	0.5981 (0.368)	0.3583 (0.305)	0.3148 (0.371)	0.3209 (0.306)	0.1429 (0.338)	0.2979 (0.302)	0.0989 (0.325)	0.3011 (0.300)	-0.0541 (0.257)	0.1591 (0.280)	0.0605 (0.319)	0.2998 (0.301)	0.4347 (0.392)	0.3258 (0.308)
Living with parents at age 14 (=1)	-4.8305*** (0.642)	-0.2812 (0.415)	-5.3551*** (0.267)	-0.2715 (0.417)	-0.4084 (0.479)	-0.2816 (0.428)	-0.0142 (0.398)	-0.3408 (0.465)	0.3000 (0.358)	-0.2955 (0.426)	0.1828 (0.308)	-0.1923 (0.415)	-0.1374 (0.326)	-0.2431 (0.415)	-0.1795 (0.521)	-0.2994 (0.445)
First child (=1)	0.0589 (0.176)	0.0518 (0.127)	0.1079 (0.120)	0.0629 (0.124)	0.3142** (0.129)	0.0520 (0.128)	0.2407* (0.129)	0.0468 (0.128)	0.1186 (0.123)	0.0591 (0.126)	0.1376 (0.111)	0.0988 (0.121)	0.2265* (0.132)	0.0978 (0.128)	0.0036 (0.177)	0.0659 (0.126)
Number of siblings	0.0464 (0.104)	0.0170 (0.070)	0.0333 (0.069)	0.0335 (0.070)	0.0054 (0.077)	0.0171 (0.071)	-0.0027 (0.067)	0.0196 (0.070)	-0.0644 (0.065)	0.0198 (0.071)	-0.0628 (0.060)	0.0202 (0.066)	-0.0162 (0.067)	0.0327 (0.070)	0.0318 (0.092)	0.0190 (0.069)
Male (=1)	0.1880 (0.203)	0.1031 (0.129)	0.0590 (0.124)	0.1000 (0.127)	-0.1458 (0.156)	0.1035 (0.129)	-0.0374 (0.137)	0.1039 (0.128)	-0.1438 (0.127)	0.1078 (0.128)	-0.2436** (0.117)	0.1520 (0.128)	-0.1970 (0.133)	0.1177 (0.131)	-0.2481 (0.180)	0.1056 (0.129)
Residential Area at age 14 (6 metropolitan cities)	0.4117 (0.332)	-0.3861** (0.164)	-0.0659 (0.201)	-0.3619** (0.164)	-0.1145 (0.249)	-0.3863** (0.164)	0.0349 (0.212)	-0.3817** (0.167)	-0.0186 (0.199)	-0.3817** (0.164)	0.0706 (0.145)	-0.3942** (0.159)	-0.0090 (0.201)	-0.3962** (0.162)	0.0387 (0.262)	-0.3919** (0.163)
Residential Area at age 14 (9 provinces and Jeju)	-0.0902 (0.262)	-0.1320 (0.188)	0.1601 (0.161)	-0.0545 (0.173)	-0.1253 (0.167)	-0.1313 (0.187)	-0.1097 (0.156)	-0.1227 (0.189)	-0.0904 (0.154)	-0.1079 (0.192)	-0.1520 (0.145)	-0.0736 (0.173)	-0.3504* (0.181)	-0.0771 (0.183)	-0.3269 (0.237)	-0.1218 (0.182)
CSAT_1	0.4330 (0.285)	-0.0316 (0.173)	0.3613 (0.241)	-0.0434 (0.174)	-0.0651 (0.187)	-0.0317 (0.175)	-0.0327 (0.175)	-0.0330 (0.173)	-0.0642 (0.175)	-0.0290 (0.173)	-0.0755 (0.158)	-0.0023 (0.169)	-0.1594 (0.193)	-0.0341 (0.170)	-0.6789** (0.292)	-0.0316 (0.174)
CSAT_2	0.2698 (0.242)	-0.0531 (0.168)	0.2447 (0.202)	-0.0636 (0.168)	-0.2032 (0.170)	-0.0529 (0.168)	-0.1996 (0.166)	-0.0503 (0.167)	-0.3708** (0.180)	-0.0499 (0.167)	-0.3957** (0.158)	-0.0178 (0.161)	-0.4842** (0.227)	-0.0608 (0.166)	-1.0693*** (0.304)	-0.0569 (0.168)
<i>Marginal Effect</i>																
Maternal employment at child's age 3	-0.0020558	-0.740756	-0.0586092		0.1446158			0.2693875		0.7473089			0.7159035		0.2129036	
Constants	-7.4533*** (0.848)	-1.1158** (0.525)	-1.3648 (0.894)	-1.1408** (0.482)	-1.4609* (0.795)	-1.1172** (0.529)	-1.2153** (0.512)	-1.0966** (0.536)	-0.6937 (0.501)	-1.1468** (0.516)	-0.5719 (0.350)	-1.1493*** (0.432)	-0.3625 (0.424)	-1.1515** (0.487)	-0.1334 (0.615)	-1.1891** (0.513)
Observations			533	533	533	533	533	533	533	533	533	533	533	533	533	533
rho:correlation between errors		-0.0451 (1.198)		1.5215 (1.000)		1.5215 (0.897)		-0.0036 (0.739)		-0.3950 (0.649)		-13.3912*** (4.936)		-1.4479** (0.734)		-0.5647* (0.294)

Table 4. Family Background and the child's educational outcomes

Variable	Whole Sample	Test Score Rank (<7)	(7<=Test Score Rank<10)	Test Score Rank(>=10)	Test Score(<7)—Test Score(>=7)	Test Score(<10)—Test Score (>=10)
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Maternal Employment at child's age 3 (=1)	0.416 (0.493)	0.405 (0.492)	0.423 (0.495)	0.325 (0.469)	0.021 (0.040)	0.091 ** (0.041)
<i>Father's Occupation at child's age 14</i>						
'LEGISLATORS, SENIOR OFFICIALS AND MANAGERS'	0.031 (0.173)	0.022 (0.146)	0.036 (0.188)	0.023 (0.149)	-0.009 (0.015)	0.008 (0.015)
'PROFESSIONALS'	0.046 (0.210)	0.038 (0.192)	0.051 (0.221)	0.102 (0.303)	-0.033 (0.021)	-0.056 *** (0.021)
'TECHNICIANS AND ASSOCIATE PROFESSIONALS'	0.073 (0.260)	0.033 (0.178)	0.102 (0.303)	0.130 (0.337)	-0.080 *** (0.025)	-0.057 ** (0.025)
'CLERKS'	0.110 (0.313)	0.092 (0.290)	0.120 (0.326)	0.192 (0.395)	-0.058 * (0.030)	-0.082 *** (0.030)
'SERVICE WORKERS'	0.079 (0.270)	0.092 (0.290)	0.069 (0.255)	0.062 (0.242)	0.026 (0.023)	0.079 (0.270)
'SALES WORKERS'	0.149 (0.357)	0.141 (0.349)	0.153 (0.361)	0.119 (0.324)	0.002 (0.030)	0.017 (0.031)
'SKILLED AGRICULTURAL, FORESTRY AND FISHERY WORKERS'	0.145 (0.353)	0.168 (0.375)	0.135 (0.342)	0.079 (0.271)	0.056 * (0.029)	0.066 ** (0.029)
'CRAFT AND RELATED TRADES WORKERS'	0.176 (0.381)	0.168 (0.375)	0.179 (0.384)	0.141 (0.349)	0.005 (0.033)	0.035 (0.381)
'PLANT, MACHINE OPERATORS AND ASSEMBLERS'	0.108 (0.310)	0.163 (0.370)	0.069 (0.255)	0.107 (0.310)	0.079 *** (0.027)	0.000 (0.027)
'ELEMENTARY OCCUPATIONS'	0.079 (0.270)	0.076 (0.266)	0.080 (0.272)	0.045 (0.208)	0.010 (0.022)	0.034 (0.023)
'ARMED FORCES'	0.004 (0.066)	0.005 (0.074)	0.004 (0.060)	0.000 (0.000)	0.003 (0.005)	0.004 (0.005)
Mother's educational attainment	2.887 (1.039)	2.762 (0.913)	2.967 (1.115)	3.407 (1.163)	-0.378 *** (0.089)	-0.520 *** (0.091)
Father's educational attainment	3.566 (1.262)	3.348 (1.173)	3.718 (1.310)	4.186 (1.383)	-0.556 *** (0.107)	-0.619 *** (0.109)
Household economic status at age 14	2.807 (0.751)	2.748 (0.750)	2.852 (0.749)	2.871 (0.719)	-0.110 * (0.061)	-0.064 (0.063)
Degree of interaction with parents at age 14	13.525 (4.451)	15.215 (5.396)	16.492 (5.522)	15.778 (4.693)	-2.232 *** (0.465)	-2.291 *** (0.417)
Extracurricular activities before school entry	0.248 (0.432)	0.229 (0.421)	0.262 (0.441)	0.345 (0.477)	-0.067 (0.037) *	-0.097 (0.037) ***

Table 5. Differences in educational outcomes depending on maternal employment

	Test score rank $\geq 10$		Test score rank $\geq 5$	
	Pr(High Test score=1   Maternal Employment =1)		Pr(Low Test score=1   Maternal Employment =1)	
	Private education (=1)	Private education (=0)	Private education (=1)	Private education (=0)
High degree of interaction with parents at age 14 (=1; more than average)	0.727 (0.353)	0.666 (0.366)	0.760 (0.197)	0.756 (0.201)
Observations	108	225	108	225
Low degree of interaction with parents at age 14 (=0; less than average)	0.550 (0.378)	0.416 (5.581)	0.681 (0.246)	0.672 (0.245)
Observations	42	156	42	156

Appendix 1. Quantile regression

Variable	Quantile Regression				
	q10	q25	q50	q75	q90
Maternal employment at child's age 3	0.0789 (0.322)	-0.1854 (0.248)	-0.1841 (0.262)	-0.3077 (0.328)	-0.2486 (0.299)
Father's educational attainment	0.1244 (0.167)	0.1571 (0.141)	0.3651** (0.146)	0.1923 (0.167)	0.1508 (0.143)
Mother's educational attainment	0.4043** (0.187)	0.3416** (0.160)	0.1540 (0.182)	0.4231** (0.199)	0.2235 (0.184)
Household economic status at age 14 (2)	1.6411* (0.864)	0.8886 (0.827)	0.5143 (0.758)	0.6538 (0.545)	1.5447*** (0.598)
Household economic status at age 14 (3)	1.3110 (0.842)	0.6813 (0.791)	-0.2889 (0.673)	-0.0769 (0.515)	1.0950* (0.613)
Household economic status at age 14 (4)	1.2010 (0.992)	0.8228 (0.880)	0.3571 (0.752)	0.0769 (0.622)	1.5140** (0.688)
Living with parents at age 14 (=1)	-1.8182 (1.596)	0.2785 (0.846)	-0.5571 (0.544)	-0.8846 (0.724)	-0.5447 (1.026)
First child	0.5670 (0.429)	0.3680 (0.321)	0.2905 (0.308)	0.5000* (0.299)	0.1257 (0.276)
Number of siblings	-0.0742 (0.197)	-0.0219 (0.144)	0.0286 (0.137)	-0.0385 (0.136)	0.0084 (0.156)
Male	-0.3780 (0.317)	-0.1927 (0.227)	0.2667 (0.313)	0.0769 (0.315)	0.1397 (0.302)
Residential Area at age 14 (6 metropolitan cities)	-0.4880 (0.402)	-0.6000* (0.333)	-0.3810 (0.423)	-0.3077 (0.388)	-0.1760 (0.358)
Residential Area at age 14 (9 provinces and Jeju)	-0.9474** (0.394)	-0.5516* (0.329)	-0.7683** (0.387)	-0.4231 (0.392)	-0.6229* (0.337)
CSAT_1	-0.3565 (0.434)	-0.5196 (0.352)	-0.4444 (0.352)	-0.0769 (0.375)	0.5391 (0.378)
CSAT_2	-1.0837*** (0.399)	-1.0858*** (0.341)	-0.8032** (0.341)	-0.3846 (0.395)	0.3827 (0.422)
Constants	3.1316** (1.352)	5.0320*** (1.173)	6.7810*** (0.944)	7.9615*** (0.850)	8.5670*** (0.833)
Observations	710	710	710	710	710
R-squared	0.0822	0.0614	0.0565	0.0629	0.0702

Appendix 2. Ordered probit

Ordered Probit (Dependent Variable: Test score of university entrance exam)			
Variable		Marginal Effect	
		Test Score Ranks	Coefficients (S.E.)
Maternal employment at child's age 3	-0.0471 (0.081)		
Father's educational attainment	0.0988** (0.043)	Rank 1	0.0001 (0.000)
Mother's educational attainment	0.1521*** (0.054)	Rank 2	0.001 (0.001)
Household economic status at age 14 (2)	0.4803** (0.190)	Rank 3	0.002 (0.004)
Household economic status at age 14 (3)	0.2410 (0.181)	Rank 4	0.003 (0.006)
Household economic status at age 14 (4)	0.2981 (0.203)	Rank 5	0.005 (0.008)
Living with parents at age 14 (=1)	-0.3507 (0.243)	Rank 6	0.005 (0.008)
First child	0.1455* (0.086)	Rank 7	0.003 (0.005)
Number of siblings	-0.0124 (0.041)	Rank 8	-0.001 (0.001)
Male	-0.0325 (0.084)	Rank 9	-0.003 (0.005)
Residential Area at age 14 (6 metropolitan cities)	-0.1408 (0.110)	Rank 10	-0.005 (0.008)
Residential Area at age 14 (9 provinces and Jeju)	-0.2659** (0.110)	Rank 11	-0.004 (0.008)
CSAT_1	-0.0720 (0.106)	Rank 12	-0.006 (0.011)
CSAT_2	-0.3106*** (0.103)		
Observations	710		
LR chi2(14)	89.05***		

Appendix 3-A. Results of two-stage least squares regressions (1)

Dependent variable: test score attained at the university entrance examination	(1)		(2)		(3)		(4)	
Eq(1)(2): 2SLS	2SLS Estimation	First-stage regression	2SLS Estimation	First-stage regression	2SLS Estimation	First-stage regression	2SLS Estimation	First-stage regression
<i>Endogenous variable</i>								
Maternal employment at child's age 3	1.9643 (2.334)		2.4279 (2.711)		2.0825 (2.387)		2.5434 (2.770)	
<i>Instrumental variable</i>								
Female Labor Force Participation Rate (By age)		0.006 ** (0.003)		0.006 * (0.003)		0.006 ** (0.003)		0.006 ** (0.003)
<i>Exogenous variables</i>								
Degree of interaction with parents at age 14			0.0954*** (0.026)	-0.005 (0.004)			0.0950*** (0.026)	-0.005 (0.004)
Private education before school entry					0.4221 (0.281)	-0.058 (0.046)	0.4158 (0.287)	-0.054 (0.046)
Father's educational attainment	0.4586** (0.210)	-0.074 *** (0.023)	0.4069* (0.231)	-0.071 *** (0.023)	0.4473** (0.210)	-0.072 *** (0.023)	0.3961* (0.232)	-0.069 *** (0.023)
Mother's educational attainment	0.2314 (0.164)	0.025 (0.032)	0.1293 (0.180)	0.033 (0.032)	0.2217 (0.167)	0.026 (0.032)	0.1199 (0.183)	0.033 (0.032)
Household economic status at age 14 (2)	0.8348 (0.550)	0.054 (0.094)	0.6974 (0.589)	0.060 (0.096)	0.7906 (0.556)	0.060 (0.094)	0.6544 (0.596)	0.065 (0.095)
Household economic status at age 14 (3)	0.1697 (0.569)	0.088 (0.092)	-0.0200 (0.619)	0.094 (0.094)	0.1321 (0.579)	0.092 (0.092)	-0.0563 (0.629)	0.097 (0.093)
Household economic status at age 14 (4)	0.4650 (0.668)	0.105 (0.105)	0.1666 (0.724)	0.109 (0.107)	0.4246 (0.677)	0.108 (0.104)	0.1275 (0.735)	0.112 (0.107)
Living with parents at age 14 (=1)	-0.4964 (0.798)	-0.094 (0.149)	-0.1984 (0.821)	-0.104 (0.148)	-0.4908 (0.814)	-0.094 (0.150)	-0.1939 (0.841)	-0.103 (0.149)
First child	0.4019 (0.245)	0.023 (0.045)	0.3830 (0.254)	0.027 (0.045)	0.3570 (0.250)	0.029 (0.045)	0.3388 (0.260)	0.032 (0.045)
Number of siblings	-0.0768 (0.134)	0.018 (0.026)	-0.0805 (0.141)	0.019 (0.026)	-0.0544 (0.133)	0.015 (0.026)	-0.0585 (0.140)	0.016 (0.026)
Male	-0.3539 (0.279)	0.050 (0.048)	-0.2758 (0.292)	0.049 (0.048)	-0.3493 (0.278)	0.049 (0.047)	-0.2717 (0.293)	0.048 (0.048)
Residential Area at age 14 (6 metropolitan cities)	0.1160 (0.430)	-0.125 ** (0.058)	0.1912 (0.487)	-0.131 ** (0.058)	0.1266 (0.434)	-0.125 ** (0.058)	0.2015 (0.493)	-0.131 ** (0.058)
Residential Area at age 14 (9 provinces and Jeju)	-0.3302 (0.301)	0.033 (0.060)	-0.3533 (0.307)	0.034 (0.059)	-0.3467 (0.306)	0.035 (0.060)	-0.3696 (0.313)	0.036 (0.060)
CSAT_1	-0.1009 (0.327)	-0.015 (0.063)	-0.1748 (0.328)	-0.004 (0.063)	-0.1400 (0.328)	-0.009 (0.063)	-0.2133 (0.330)	0.001 (0.063)
CSAT_2	-0.7291** (0.307)	-0.014 (0.061)	-0.8273*** (0.317)	-0.002 (0.061)	-0.7684** (0.311)	-0.009 (0.061)	-0.8661*** (0.322)	0.003 (0.060)
Constants	5.0161*** (1.349)	0.243 (0.183)	3.9510** (1.617)	0.302 (0.191)	4.9754*** (1.369)	31.571 (24.682)	3.9149** (1.638)	0.302 (0.191)
Observations	533		531		533		531	
F Test of all explanatory variables	4.52***	2.68 ***	4.76***	2.63 ***	4.26***	2.64 ***	4.52***	2.58 ***
F Test of excluded instruments		4.72 **		3.72 *		4.59 **		3.62 *
Hansen's J test	<i>equation exactly identified</i>		<i>equation exactly identified</i>		<i>equation exactly identified</i>		<i>equation exactly identified</i>	



Appendix 3-B. Results of two-stage least squares regressions (2)

Dependent variable: test score attained at the university entrance examination	(1)		(2)		(3)		(4)	
Eq(1)(2): 2SLS	2SLS Estimation	First-stage regression	2SLS Estimation	First-stage regression	2SLS Estimation	First-stage regression	2SLS Estimation	First-stage regression
<i>Endogenous variable</i>								
Maternal employment at child's age 3	1.4528 (1.543)		1.4239 (1.589)		1.6831 (1.601)		1.6495 (1.648)	
<i>Instrumental variable</i>								
Female Labor Force Participation Rate (By age)		0.006 ** (0.003)		0.005 * (0.003)		0.006 ** (0.003)		0.005 * (0.003)
Mother's employment rate of the child's birth place		0.597 ** (0.251)		0.613 ** (0.252)		0.575 ** (0.251)		0.592 ** (0.252)
<i>Exogenous variables</i>								
Degree of interaction with parents at age 14			0.0900*** (0.022)	-0.005 (0.004)			0.0903*** (0.023)	-0.005 (0.004)
Private education before school entry					0.3978 (0.259)	-0.047 (0.046)	0.3656 (0.252)	-0.043 (0.046)
Father's educational attainment	0.4214*** (0.162)	-0.072 *** (0.023)	0.3370** (0.159)	-0.069 *** (0.023)	0.4194** (0.164)	-0.070 *** (0.023)	0.3361** (0.162)	-0.067 *** (0.023)
Mother's educational attainment	0.2433 (0.154)	0.020 (0.032)	0.1613 (0.155)	0.028 (0.032)	0.2313 (0.157)	0.021 (0.032)	0.1490 (0.159)	0.029 (0.032)
Household economic status at age 14 (2)	0.8724* (0.529)	0.050 (0.093)	0.7754 (0.544)	0.057 (0.095)	0.8220 (0.537)	0.055 (0.093)	0.7280 (0.552)	0.061 (0.095)
Household economic status at age 14 (3)	0.2247 (0.527)	0.085 (0.091)	0.0920 (0.540)	0.091 (0.093)	0.1765 (0.538)	0.088 (0.090)	0.0463 (0.551)	0.094 (0.092)
Household economic status at age 14 (4)	0.5290 (0.618)	0.111 (0.104)	0.2934 (0.630)	0.116 (0.106)	0.4760 (0.629)	0.114 (0.103)	0.2434 (0.642)	0.118 (0.106)
Living with parents at age 14 (=1)	-0.5377 (0.754)	-0.106 (0.145)	-0.2913 (0.729)	-0.117 (0.144)	-0.5229 (0.774)	-0.105 (0.145)	-0.2759 (0.750)	-0.116 (0.145)
First child	0.4070* (0.237)	0.019 (0.045)	0.3985* (0.236)	0.022 (0.045)	0.3635 (0.243)	0.024 (0.045)	0.3577 (0.242)	0.027 (0.045)
Number of siblings	-0.0640 (0.120)	0.006 (0.026)	-0.0553 (0.119)	0.007 (0.026)	-0.0459 (0.122)	0.004 (0.026)	-0.0391 (0.120)	0.005 (0.026)
Male	-0.3258 (0.253)	0.037 (0.047)	-0.2223 (0.249)	0.035 (0.048)	-0.3280 (0.255)	0.037 (0.047)	-0.2253 (0.252)	0.035 (0.048)
Residential Area at age 14 (6 metropolitan cities)	0.0511 (0.346)	-0.135 ** (0.058)	0.0572 (0.347)	-0.142 ** (0.058)	0.0762 (0.353)	-0.134 ** (0.058)	0.0827 (0.353)	-0.141 ** (0.058)
Residential Area at age 14 (9 provinces and Jeju)	-0.3178 (0.288)	-0.045 (0.068)	-0.3263 (0.282)	-0.045 (0.067)	-0.3363 (0.295)	-0.040 (0.068)	-0.3439 (0.288)	-0.041 (0.068)
CSAT_1	-0.1102 (0.314)	-0.008 (0.063)	-0.1816 (0.303)	0.003 (0.063)	-0.1449 (0.318)	-0.004 (0.063)	-0.2146 (0.309)	0.006 (0.063)
CSAT_2	-0.7271** (0.295)	-0.019 (0.061)	-0.8119*** (0.291)	-0.006 (0.061)	-0.7646** (0.301)	-0.014 (0.061)	-0.8479*** (0.297)	-0.002 (0.061)
Constants	5.2464*** (1.041)	0.102 (0.189)	4.4411*** (1.109)	0.160 (0.196)	5.1545*** (1.062)	0.109 (0.189)	4.3488*** (1.129)	0.165 (0.196)
Observations	533		531		533		531	
F Test of all explanatory variables	4.90***	3.03 ***	5.67***	2.96 ***	4.56***	2.89 ***	5.32***	2.82 ***
F Test of excluded instruments		5.24 ***		4.84 ***		4.97 ***		4.61 **
Hansen's J test	0.105		0.295		0.060		0.219	

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