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PRESCHOOL EDUCATION AS A DETERMINANT OF EDUCATIONAL ATTAINMENT: AN ANALYSIS OF SERBIA

ABSTRACT: *The subject of this paper is preschool education as a determinant of students' educational attainment in Serbia and factors that influence whether a Serbian child is included in preschool programmes. This paper aims 1) to assess how attendance of preschool programmes in Serbia affects a student's educational attainment in terms of mathematical, reading, and scientific literacy; 2) to explore how preschool education differs for students who occupy different positions in the distribution of educational attainment; and 3) to examine the determinants of a child in Serbia receiving preschool education. The analysis is based on data from PISA2012 testing. In order to assess the significance and nature of the effect of preschool education on educational attainment in terms of mathematical, reading, and scientific literacy we use unconditional quantile regression. To analyse factors that affect whether a child is included in the preschool programme we apply probit regression. Unconditional quantile regression results suggest that the sign and intensity of the effect of preschool education for more than a year are positive and increasing. The results of the probit regression show that socio-economic family background and parental status in the labour market are the factors that determine whether the student will attend preschool education for more than a year. The results indicate that the educational system in Serbia reproduces poverty and social exclusion.*

KEY WORDS: *preschool education effects, educational attainment, PISA, unconditional quantile regression, probit regression, Serbia*

JEL CLASSIFICATION: I21, I24

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1. INTRODUCTORY CONSIDERATIONS: THEORETICAL AND EMPIRICAL EVIDENCE ON THE IMPORTANCE OF EDUCATION QUALITY FOR ECONOMIC GROWTH

Education development is a fundamental way of generating sustainable economic growth, employment, and earnings in modern knowledge-based economies. The returns on investment in education translate into economic growth and improve the quality of society. Education influences children's attitudes and assists them in growing up with social values that benefit both themselves and the nation at large. Neglecting the economic dimension of education endangers the prosperity of future generations, with numerous consequences for 1) poverty, 2) social inclusion, and 3) the financial sustainability of the social security system.

From a theoretical perspective, education is viewed as an investment in knowledge and skills. The benefit of its impact at the individual level can take many forms. The main expected return is increased individual productivity: educated individuals earn higher wages and less likely to be unemployed. Increased productivity derived from education increases cognitive skills that help people to more easily understand, perform, and improve economic processes (Hanushek and Woessmann 2008, 2015). Education also affects non-cognitive skills and personality characteristics such as persistence, locus of control, and patience, and may influence economic payoffs (Almlund 2011). Oeropulos and Salvanes (2011) review the non-pecuniary benefits of education other than those that come from increased productivity, such as increased work satisfaction, better parenting, improved resolution of health issues, and reduced crime.

At the macroeconomic level there are two classes of theoretical models that explain the mechanisms by which education can spur economic growth in the long run. Augmentative growth models are based on the microeconomic theory of human capital in which increased individual productivity aggregates at the economy level: education simply increases macroeconomic productivity through the accumulation of human capital (Mankiw, Romer, and Weil 1992). In endogenous models, sustained growth comes from inventing, marketizing, and diffusing new ideas and technologies originated by the highly educated (Aghion and Howitt 1998).

Until recently most empirical research on economic returns to education measured the quantity of schooling. The standard method of estimating the

effect of education on economic growth was to estimate cross-country growth regressions, where average annual growth in GDP over several decades is a function of schooling and a set of variables seen as important for growth (e.g., rate of enrolment, drops in or average duration of schooling). Barro (1991, 2001), Mankiw et al., (1992) and early research using cross-country regressions find a significant positive association between measures of schooling and economic growth. Meanwhile, several questions have arisen regarding this relationship. Bils and Klenow (2000) raise the issue of causality and Pritchett (2006) highlights the importance of including other factors when accounting for economic growth. However, the two most important questions regard the limits of the previous growth models. First, they implicitly assume that a year of schooling yields the same increase in knowledge and skills regardless of the quality of the country's education system. A student in Algeria or the Dominican Republic (countries with the lowest achieving students in international education rankings) does not gain the same amount of knowledge or skill in any year of schooling as a student in Singapore or Hong Kong (countries with the highest achieving students in international education rankings). Measuring the effect of years of schooling on economic growth assumes that students from these two groups of countries are equivalent. The second drawback is the implicit assumption that formal schooling is the primary source of education and that a variety of factors outside of school (e.g. family and peers, the quality of the environment) do not affect educational attainment.

Over the past ten years the development of international programmes for the evaluation of educational attainment, such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), have refocused the attention of researchers away from the quantity of schooling or time spent in school and toward the quality of education and estimating of level of skill students actually gain. Using the data from these international student attainment tests to build a measure of education quality, Hanushek and Kimko (2000) were the first to find a statistically and economically positive effect of the quality of education on economic growth that was larger than association between quantity of schooling and growth. Later studies such as Barro (2001), Woessmann (2002, 2003), Bosworth and Collins (2003), and Coulombe and Tremblay (2006) confirm that the quality of education, measured by knowledge that students gain as depicted in tests of cognitive skills, is far more important for economic growth than quantity of education. An OECD report (2010) underscores the importance of quality education for the development of the national economy, stating that

improving the quality of education should be a primary goal for achieving sustainable development. Based on PISA measurements, the report presents projections of the benefit to countries of improving educational achievement. One projection is based on the assumption that an improvement in the results of each individual OECD country in the PISA test by a quarter of a standard deviation, or 25 points, will result in an overall increase in GDP of 115,000 billion USD PPP (expressed in the current value of the future increase in GDP up to 2090). Another, less optimistic projection posits that if each individual OECD country had scored 546 points in the PISA test and reached the Finnish level by 2000, this would have resulted in an overall increase in GDP of 260,000 billion USD PPP (expressed in the current value of the future increase in GDP up to 2090).

The most recent evidence (Hanushek and Woessmann 2015) adds a new international student achievement test and uses the most recent economic growth data to estimate the even longer period of 1960–2009. The average educational performance of the whole labour force and overall cognitive skills – not just those built in schools, which are a simple average of the mathematics and science scores from international tests – are taken as a proxy for the measure of educational quality and included in the growth analysis. After controlling for the initial level of GDP per capita and for years of schooling, the test scores show a statistically significant effect of real GDP per capita on growth in 1960–2009. For every half standard deviation in test scores, which is equivalent to 50 points on the PISA scale, a country's long-term growth is 1 percentage point higher. Hanushek and Woessmann's (2015) model accounts for about three-quarters of the total cross-country variation in economic growth over the past half-century. When, instead, the education of a population is measured by average years of education, the association with economic growth is much weaker and the model accounts for only one quarter of the cross-country variation in long-run growth. The effect of education quality is significantly statistically larger in low-income countries than in high-income countries: therefore, once developing countries have a high-quality school system, it pays to keep children in school longer – but only if the school system produces better knowledge and skills. This evidence strongly supports the need to focus on educational attainment (Woessmann 2014).

The results of the aforementioned studies regarding the importance of quality education at the macro level show that educational systems should be reformed with the aim of improving educational achievement. Therefore, educational

policymakers must be aware of the factors that affect students' academic achievement and determine educational quality. Many studies of these determinants have been based on the economic tradition that assumes an analogy between industrial and educational processes, and that resources invested in education can be transformed by teachers and students into educational outcomes in a uniform way. Coleman (1966) encouraged this type of educational quality analysis by introducing statistical methods to establish a connection between invested resources and educational outcomes. A large number of studies (e.g., Hanushek and Kimko 2000; Lee, Zuze, and Ross 2005; Willms 2006; Dolton and Marcenaro-Gutierrez 2011) have observed how the quality of education depends on 1) spending on education, 2) the salaries, qualifications, and experience of teachers, and 3) average class sizes. These studies, conducted in both developed and developing countries, have not succeeded in explicitly singling out the key determinants of student achievement. However, an increasing number of studies (e.g., Sammons et al. 2002; Esping-Andersen 2009; Mullis et al. 2012; Green and Mosafa 2012; OEC, 2013) suggest that preschool education has a significant impact on educational attainment.

The subject of this paper is preschool education as a determinant of the educational attainment of students in Serbia and the factors that influence whether a child is included in the preschool programme.[1] This paper aims 1) to assess how the preschool programme affects educational attainment in terms of mathematical, reading, and scientific literacy; 2) to explore whether preschool education affects students in the various parts of the distribution of educational attainment differently; and 3) to examine what determines whether a child receives preschool education.

This paper is organized as follows. After the introduction, the second part reviews the literature on the importance of investing in early childhood education and care. The third part describes the data used. The fourth part presents the empirical model and the methods used to assess the impact of preschool education on educational attainment, and identifies the factors that influence whether a child is included in the preschool programme in Serbia. The fifth part presents the results of the analysis. The final part of the paper gives conclusions and comments.

[1] Preschool education in Serbia is the education and care of children between 6 months and 7 years old.

2. LITERATURE REVIEW: WHY INVEST IN EARLY CHILDHOOD EDUCATION AND CARE?

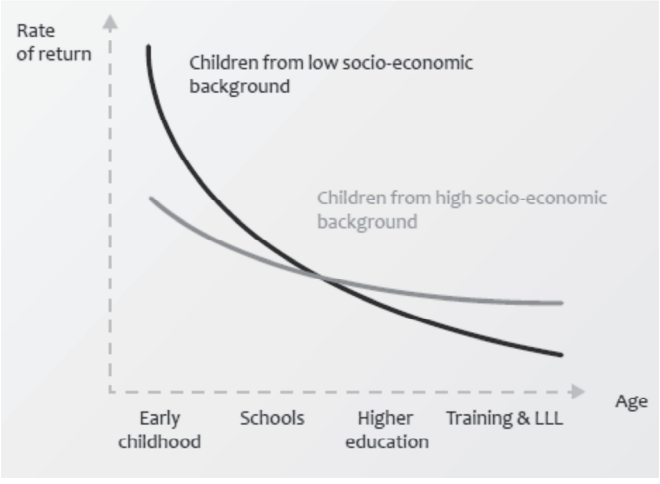
A large body of research from a variety of economic disciplines demonstrates that early childhood education and care (ECEC) provides the foundation for later academic and social success. Early childhood education and care can accelerate economic growth and promote more equal opportunities over time. A strong consensus has developed among experts who have analysed high quality early preschool programmes: for example, longitudinal studies like The Perry Preschool Program and The Abecedarian Project in the United States, and Effective Preschool, Primary and Secondary Education Projects (EPPSE) in England. These programmes have a large number of important lasting benefits for participants, their families, and society at large, relating to the positive effect of early environmental experiences on cognitive and non-cognitive skills, achievement, job performance, and social behaviour long after the programme has ended. The short- and long-term positive effects of preschool education have been found to be that 1) attending preschool improves children's academic and social attainment by providing them with an early start; 2) preschool education continues to influence attainment throughout primary and secondary school, with children proceeding to higher education; 3) the positive influence is greater for children from disadvantaged families who have a less stimulating home environment or parents with poor or no qualifications (Taggart et al. 2015).

Investment in preschool programmes pays for itself over time by generating high rates of return for participants and for the non-participating public and government. Lynch and Vaghul (2015) show that for children from the United States, well-designed preschool programmes generate an average of $3 or more in present value benefits for every dollar of investment. (Present value estimates are the value in today's dollars of future revenues discounted at a specified rate of interest.) There is also a lot of evidence that while participants and their families get part of the total benefit, the benefit to the rest of the public and the government can be larger and tends to outweigh the cost of these programmes (Allen 2011). For example, Fairholm (2009) estimates a benefit cost ratio of 2.54:1 for the Canadian early childhood sector.

Heckman (2003), Nobel Laureate in Economic Science 2000, wrote: "We cannot afford to postpone investing in children until they become adult, not can we wait until they reach school age…The returns to human capital investment are greatest for the young for two reasons: (1) younger persons have a longer

horizon over which to recoup the fruits of their investment and (2) skill begets skill." Figure 2.1 shows the so-called Heckman curve. Heckman found that investment in learning in a child's early years yields much higher returns than investing later in life. For example, Cunha et al. (2006) calculate that $1 invested in ECEC returns 3 times as much as $1 invested in school-age children and 8 times as much as $1 dollar invested in adult education. Moreover, the Heckman curve illustrates that the preschool education effect is stronger for children from low socio-economic family backgrounds than for children from high socio-economic family backgrounds. The explanation is that a child of well-educated employed parents is more likely to have a stimulating home environment with lots of toys, books, and communication media, so enrolling this child in a preschool programme is unlikely to stimulate child development much further than is the case in the home environment. By contrast, preschool education for a child of two not-so-well-educated unemployed parents has a significant impact on child development, since that child's home environment is not stimulating (UNICEF 2012). Heckman (2008) and Woessmann (2014) argue that to address the gaps in educational attainment, social policy should be directed toward the malleable early years and disadvantaged children.

Figure 2.1: Heckman curve – Rates of return on investment in education at different ages of a child



Source: Adapted from Woessmann (2006)

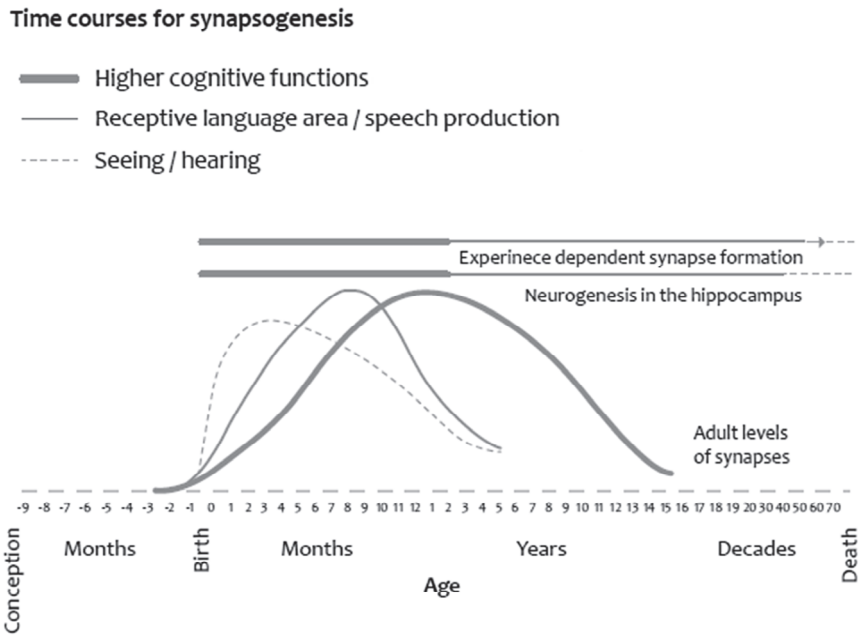
In the report PISA in Focus (2011), the OECD emphasizes that preschool education has the strongest effect in countries that offer primary education to a

large percentage of the population, do so over a long period of time, have smaller pupil-to-teacher ratios, and invest more per child at the preschool level. In particular, children who participate in high quality preschool programmes tend to have higher scores in maths, reading, and science achievement tests. They are better prepared to enter primary school, experience less grade retention, and have less need for special education and other remedial course work. They also have lower dropout rates, higher high school graduation rates, and higher levels of schooling attained. As adults they have higher employment rates, higher earnings, greater self-sufficiency and lower welfare dependency, lower involvement in the criminal justice system, and better health outcomes. Parents and families of children who participate in preschool programmes also benefit and the programmes have a positive impact on their labour supply. Parents complete more years of schooling, have higher high school graduation rates, are more likely to be employed by balancing family and work responsibility, and have higher earnings.

Why does this happen? There is a vast amount of research linking early learning opportunites to children's development outcomes. Heckman (2008) argues that the key to early childhood programmes is their effectiveness in improving not only hard skills but also soft skills. Hard skills are skills such as maths, reading, and science literacy, typically measured by standardized tests. Soft skills are character and social skills, including self-confidence, getting along with peers and authority figures, and the ability to plan. Both types of skill are important in determing worker productivity, and soft skills are increasingly demanded by employers. The development of soft and hard skills early in life leads to greater success in each subsequent grade, or, as Heckman says, “skill begets skill”.

These findings are based on the new knowledge and understanding that during the prenatal period and infancy, physical brain development occurs at a faster pace than at any other time in a person's development. During the first three years of life, brain connections develop quickly and set the developmental trajectories that influence life-long learning, behaviour, and health (Irwing et al. 2007). Figure 2.2 shows the pattern of brain development from conception to age 16 for three main functions: 1) seeing and hearing, 2) language, and 3) higher cognitive functions. To be clear, this concerns the development of the brain’s capacity to acquire certain skills, not these skills as such (UNICEF 2012).

Figure 2.2: Time pattern of brain synapse formation



Source: Adapted from Shoenkoff and Phillips (Eds.) (2000)

But what can we say about the predictors of optimal preschool education? Many factors contribute to the early education experience of children. They can be influenced by economic and social determinants. The Report of the State of Public Health in Canada (2009) identifies socio-economic status as an individual's and group's position within society, dependent upon a combination of factors including occupation, level of income, level of individual education in the household, wealth, and place of residence.

Useful insights are provided by the OECD's (2016) newest background brief on inequalities in the use of formal ECEC. In many OECD countries, children are more likely to use ECEC when they come from relatively advantaged socio-economic family backgrounds. In other words, a high percentage of children from socio-economic disadvantaged families are not included. The chances of a child under three years participating in formal ECEC increases with household income. In France and Ireland, participating rates for children from low-income families are less than a quarter of those for children from high income families (81% and 57% respectively), and in Belgium and the Netherlands participation

rates of the poorest children are only around half of those for children from the richest families (69% and 72% respectively). Also indicative are findings that in a few countries (Denmark, Ireland, and Sweden), very young children's participation in formal ECEC differs neither with income nor with maternal level of education, but remains high in both cases. It is not houshold income or maternal education themselves that explain differences in the use of ECEC, but rather their relationship with maternal emloyment: children are far more likely to use ECEC services when the mother works. This is largely because employment increases the demand for non-parental education and care. In many countries, differences in participation across levels of both maternal education and household income decrease radically after the employment status of the mother is taken into account.

In a recent paper by Vujić and Baronijan (2013) based on PISA data for Serbia, preschool education has a positive effect on later educational success even when comparing students from similar socio-economic backgrounds. However, in a sample of male pupils, the positive effect of preschool attendance on school performance disappears once the authors control for factors of socio-economic background, while in a sample of female pupils, the positive effect of preschool attendance on school performance remains significant even after the authors control for factors of socio-economic background. These results indicate the importance of children's family characteristics. Many studies find a positive correlation between students' socio-economic status and their educational outcomes, meaning that students with higher socio-economic status on average have higher school achievement. Baucal (2012), for example, investigates the direct and indirect impact of socio-economic status on educational achievement in Serbia using PISA2009 data.

3. DATA

The analysis is based on data from the 2012 PISA test for Serbia. This is the last PISA test that included Serbia.

The main goal of the PISA test is to assess and monitor the extent to which students who have completed primary education master important competencies for further education and active participation in the community. The literacy of a fifteen-year-old is tested in three different domains: 1) mathematical literacy, 2) reading, and 3) scientific literacy. The quality of education is not measured by the degree to which students can reproduce what

they have learned in school, but by their capability to understand and use information in solving problems of everyday life. Therefore, this programme is broader than other programmes that evaluate education quality. For example, TIMSS testing focuses on the curriculum, while PISA aims to test the efficiency of education systems in developing competencies that are important for the personal development of not only students but also the community. PISA focuses on competence, so testing is not directed at monitoring the implementation of the curriculum. Although these are competencies that are supported by the curriculum, education quality is perceived as an interdisciplinary and functional category because reading and mathematical and scientific literacy are developed through interaction with other people and are influenced by numerous other contextual factors (Baucal 2013).

The most important criterion for the selection of participants in PISA testing is students' age: students who are 15 years old are eligible for testing. Selection of participants is defined by age rather than years of schooling as the organization of education systems differs, and otherwise samples from different countries would not be comparable. First, the schools that will participate in the test are chosen, and then students are randomly selected from these schools. In most countries, most of these students are in in the first year of high school. Therefore, when we talk about PISA we think primarily of high school, although one should bear in mind that a small percentage of students are still in primary school. A pattern for all participating countries is formed according to the same principles, thus ensuring that it is representative. It is worth noting that in addition to testing, especially important are the questionnaires that are completed by students, their parents, and their school. These questionnaires collect data on various factors that may be relevant to students' academic achievement and which can be used to define different strategies for improving the quality of education. Studies that follow the academic and professional development of students with the aim of identifying determinants of educational quality could not be conducted without this data.

PISA testing in Serbia in 2012 covered about 4,700 fifteen-year-olds from 153 schools. Students from Serbia achieved on average 449 PISA points in maths literacy, 446 in reading, and 445 in science literacy. Serbian students lag behind

students from OECD countries by 1 to 1.5 school years on average, according to the literacy domains observed.[2]

It is important to examine differences in the educational achievements of students from different socio-economic backgrounds in order to understand the necessity of equality in the education system and the necessity of providing access to quality education for students from socioeconomically vulnerable families. Table 3.1 shows that students in the highest socio-economic quartile achieved 415 PISA points in mathematical literacy, 416 in reading, and 417 in scientific literacy. Students in the lowest socio-economic quartile achieved 79 PISA points in mathematical literacy, 71 in reading, and 66 in scientific literacy. The socio-economic quartiles were determined by values of the index of the economic, social, and cultural status (ESCS) of a student's family.[3] A student who belongs to the lowest quartile of the ESCS index lags 1.5 to 2 school years on average in terms of educational achievement in the tested domains, compared to students who belong to the highest quartile. Therefore it is particularly important to examine the factors that determine educational quality so that policymakers can define the measures necessary to promote equality of education in Serbia, with the aim of improving the educational achievement of students from socioeconomically disadvantaged backgrounds.

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[2] One school year corresponds to 40 PISA points.

[3] The index of the economic, social, and cultural status (ESCS) of a student's family is a standardized scale where 0 indicates the average socio-economic status of students in OECD countries. The standard deviation of this particular scale is 1. If a student has a score of –1 on this scale it means 1) that the socio-economic status of this student is lower than the socio-economic status of an average student in OECD countries, 2) that 1 in 6 individuals in OECD countries have lower socio-economic status than this student, and 3) that 5 out of 6 individuals in OECD countries have a higher socio-economic status than this student. Similarly, if a student has a socio-economic status of +1 this means 1) their socio-economic status is higher than the that of the average student in OECD countries, 2) 5 out of 6 students from OECD countries have lower socio-economic status than this student, and 3) 1 out of 6 students in OECD countries have lower socio-economic status than this student. This index was derived from five other indices: the highest occupational status of parents, the highest educational level of parents, family wealth, cultural possessions, and home educational resources. For more details on the methodology of the ESCS index see PISA2012 Technical Report, OECD Publishing (2014).

Table 3.1: The difference in educational achievement of students from the highest and lowest socio-economic quartiles, Serbia, PISA2012

Tested domain	Highest socio-economic quartile	Lowest socio-economic quartile	Difference
Mathematical literacy	415	494	79
Reading literacy	416	487	71
Scientific literacy	417	483	66

Source: Authors' calculations based on PISA2012 data

Preschool education is also the subject of this analysis. As shown in Table 3.2, data from the PISA2012 test for Serbia shows significant differences in preschool programme coverage of children from different socio-economic backgrounds. Almost one-third of students from the highest socio-economic quartile (according to ESCS index values) received no preschool education, while only one-tenth of students from the lowest socio-economic quartile attended preschool programmes. The difference is even more apparent when observing the length of time spent in preschool. Of the total number of participants in PISA2012 testing in Serbia, around 35% of children from the poorest families and 70% of children from the richest families attended preschool for more than a year. Thus, half as many students from socioeconomically disadvantaged families attended preschool for more than a year than students from the richest families. Therefore the difference in educational achievement between students from the different socio-economic quartiles is unsurprising.

Table 3.2: Preschool programme coverage of students from the highest and lowest socio-economic quartiles according to PISA2012 (in %)

Attendance of preschool programme	Highest socio-economic quartile	Lowest socio-economic quartile
Have not attended preschool programme	28.4	11.3
Have attended preschool programme	71.6	88.7
Have attended preschool programme for less than a year	63.8	32.6
Have attended preschool programme for more than a year	36.2	67.4

Source: Authors' calculations based on PISA2012 data

4. EMPIRICAL MODEL

To analyse of the impact of preschool education on the educational attainment of students in Serbia the following regression equation is estimated:

$$EA_{ij}=\alpha+\beta PE_{ij}+\gamma PC_{ij}+\delta FC_{ij}+\varepsilon SC_{ij}+\zeta_{ij}, \quad (4.1)$$

where EA_{ij} is a dependent variable representing the result of student *i* from school *j* in PISA2012 testing of mathematical literacy, reading, and scientific literacy;[4] PE_{ij} is an independent variable representing whether student *i* from school *j* has attended a preschool programme for more than a year;[5] PC_{ij} is a set of independent variables which represent the personal characteristics of student *i* from school *j*; FC_{ij} is a set of independent variables which represent the family characteristics of student *i* from school *j*; SC_{ij} is a set of independent variables which represent the characteristics of school *j* which student *i* is attending. The above regression equation represents a production function of education, since the educational attainment of students, i.e., output, is observed as a function of the various factors that are important to the educational attainment, i.e., inputs.

When using the production function of education, as cited in the literature (e.g., Manx 1993; Rangvid 2007), a reflection problem may occur, making it impossible to obtain unbiased estimates. The reflection problem is often the result of omitting relevant variables from the analysis (Manski 1993).[6] Specifically, we assume that the set of variables correlated with the student's personal characteristics, PC_{ij}, characteristics of the student's family, FC_{ij}, and characteristics of the school the student is attending, $SC_{ij,}$ can be decomposed into two parts: 1) the variables that are easily distinguishable to a researcher, PC_{1ij}, $FC_{1ij,}$ and SC_{1ij}, such as the sex of the student, the family structure, or the

[4] As there are multiple estimates of the dependent variable in PISA testing referred to as 'five plausible values', PV commands in Stata statistical software were obtained for estimation. For more details about these commands see: http://fmwww.bc.edu/RePEc/bocode/p/pv.html.

[5] Some papers (e.g., Camilli et al. 2010; van Huizen and Plantenga 2012; Kay and Pennucci 2014; Melhuish et al. 2015) confirm a statistically significant and positive impact of attending preschool for more than a year, following the assumption that the effect of preschool mostly manifests when the child is included in this programme for longer periods of time. This paper adopts this assumption and also analyses the effects of attending preschool education for more than a year.

[6] For more details about the reflection problem, of see: Manski, C. (1993). Identification of Endogenous Social Effects: The Reflection Problem. *The Review of Economic Studies*, vol. 60 (3), pages 531-542.

size of the school the student is attending, and 2) variables that are barely distinguishable to a researcher, PC_{2ij}, $FC_{2ij,}$ and SC_{2ij}, such as student's ambition, parents' support, or the availability of educational and other materials at the school the student attends. If the second component, i.e., the variables that are barely distinguishable to a researcher, were omitted from the analysis of preschool education effects we would estimate a regression equation in which the random error of regression, η_{ij}, contains a random component and effects of these barely distinguishable characteristics:

$$EA_{ij}=\alpha+\beta_1 PE_{1ij}+\gamma_1 PC_{1ij}+\delta_1 FC_{1ij}+\varepsilon_1 SC_{1ij}+\eta_{ij} \quad (4.2)$$

where

$$\eta_{ij}= \zeta_{ij}+ \beta_2 PE_{2ij}+\gamma_2 PC_{2ij}+\delta_2 FC_{2ij}+\varepsilon_2 SC_{2ij} \quad (4.3)$$

In other words, the assessment of preschool education effects, β, would be biased. Therefore, in order to overcome the reflection problem, the analysis includes a large number of control variables for both easily and barely distinguishable personal characteristics: characteristics of the student's family and characteristics of the school the student attends. Overcoming the reflection problem in this way is possible thanks to the large database created by PISA testing, based on questionnaires filled in by students, their parents, and school principals. The following control variables are included: gender, age, grade, index of student's attitude towards school, index of economic, social, and cultural status of the family, family structure, index of parental occupation status, index of parental education level, school type, school location, school size, class size, index of school responsibility for curriculum, index of school responsibility for resources, quality of school physical infrastructure index, and quality of school education resources index. The OECD created these indices based on answers to questions in the PISA questionnaires.

In this way, equation (4.1) was estimated by weighted least squares regression and unconditional quantile regression.

Because the sample has two strata, the first of schools and the second of students, we use sample weights to evaluate the effect of preschool education.[7] The selection of students to participate in the PISA testing process consists of

[7] For more detail on the sample design, see the PISA2012 Technical Report.

several stages. The first stage is the selection of schools so that all regions and types of school are covered proportionally. The second stage is selecting the students from a list of fifteen-year-olds which is submitted by each chosen school from the previous stage. Based on the submitted list, up to 35 students are chosen randomly to participate in the testing.[8]

Weighted least squares regression only allows us to estimate the average effect of attending preschool on the academic achievement of students, and not whether these effects are different for students in different parts of the educational achievement distribution. Therefore, unconditional quantile regression is used to determine the nature of preschool education effects on the quality of students' education, which allows us to determine whether these effects are different, for example, in the case of a student who belongs to the first quartile and in the case of a student who belongs to the last quartile of distribution of educational achievement. In other words, we want to estimate whether the preschool education effect is increasing or decreasing.

Firpo, Fortin, and Lemieux (2009) introduced unconditional quantile regression as a new method developed for empirical purposes, which estimates the impact of changing the distribution of explanatory variables, X, on the unconditional quantiles of the outcome variable, Y. The unconditional quantiles are the quantiles of the marginal distribution of the outcome variable Y. The authors assert that the conditional quantile regression introduced by Koenkar and Basset (1978) does not give interesting effects. This is because the τ^{th} unconditional quantile of Y might not be the same as the τ^{th} conditional quantile of Y|X.[9] As these authors state, empirical researchers are often interested in changes in the quantiles, q_τ, of the unconditional distribution, F_Y, because in most cases conditional quantile regression may generate results that are often not generalizable or interpretable in, for example, an education policy context. In this paper we want to estimate the direct effect, $dq_\tau(p)/dp$, of attending preschool education, p=Pr[PE=1], on the τ^{th} quantile of the unconditional distribution of educational attainment, EA.[10] Therefore,

[8] When the selected school has less than 35 fifteen-year-old students, all of them participate in the testing.

[9] The notation τ represents any quantile.

[10] Put differently, the 1st quartile=0.25 quantile (splits off the lowest 25% of the data from the highest 75%), the 2nd quartile=0.50 quantile (cuts the data in half), the 3rd quartile=0.75 quantile (splits off the highest 25% of data from the lowest 75%).

unconditional quantile regression provides us with more interpretable results for making recommendations regarding education policy.

To analyse the factors that affect whether a Serbian student who participated in PISA2012 testing attended a preschool programme for more than a year we estimated the regression equation:

$$PE_{ij}=\alpha+\beta ESCS_{ij}+\gamma PEL_{ij}+\delta PLS_{ij}+\zeta_{ij} \quad (4.4)$$

where PE_{ij} is a dependent variable describing if a student *i* from school *j* attended preschool for more than a year; $ESCS_{ij}$ is an independent variable of the socio-economic family status of a student *i* from school *j*, PEL_{ij} is a set of independent variables related to the educational level of the mother and father of a student *i* from school *j*, and PLS_{ij} is a set of independent variables related to the labour market status of the mother and father of a student *i* from school *j*. The dependent variable takes the value PE = 1 if the student attended preschool for more than a year, and PE = 0 if the student attended preschool for less than a year or had no preschool education. As the dependent variable is in fact a binary variable, this particular regression equation (4.4) was assessed by probit regression. We decided to evaluate using the probit model rather than the logit model because the probit model is more appropriate, as most economic variables follow a normal cumulative function rather than a logistic function. It should be noted that the procedures of both models are very similar and that significantly different results from these procedures are rare (Asteriou and Hall 2011).

A description of the variables used to analyse the impact of attending preschool for more than a year on students' educational attainment and the factors that influence the likelihood of attending preschool for more than a year, and the summary of their statistics are presented in Table A1 in the Appendix.

5. RESULTS

Before discussing the analysis results it should be noted that the performed tests showed no heteroskedasticity and autocorrelation problems.

Table A2 shows the results of the analysis of the effect of the average preschool education on educational attainment, based on the PISA2012 testing and estimated by using weighted least squares regression. The results indicate that

the effects of attending preschool for more than a year are statistically significant and positive: the educational attainment in mathematical literacy, reading, and scientific literacy of a student who attended preschool for more than a year was, on average, around 17, 15, and 14 PISA points better, respectively, than for a student who did not attend preschool. In other words, this result indicates that the education quality of a student who did not attend preschool lags behind by between one-third and one-half of a school year, depending on the literacy domain observed. Thus, the average effect of attending preschool in Serbia is significant in terms of educational quality: preschool education is an important determinant of a student's attainment in terms of mathematical, reading, and science literacy.

In addition to the average effects of the preschool programme, the effects of the control variables should be mentioned.

The impact of most variables related to students' individual characteristics is statistically significant and has a sign in the expected direction. The average male student achieves results that are 11 PISA points better for mathematical literacy, and approximately 23 and 10 PISA points worse for reading and scientific literacy, respectively, than the average female student. The influence of age on students' academic achievement is statistically significant and positive only in the case of scientific literacy: the student who is one year older achieves better results in science literacy by 9 PISA points. On the other hand, the grade impact on students' academic achievement is statistically significant and positive for mathematical and reading literacy but not for scientific literacy. The average student who has attended one grade more achieves better results in terms of mathematical and reading literacy, by 28 and 23 PISA points, respectively. It is worth noting that a student's ambition, observed through an index of students' attitude towards school, to a large extent explains the differences in students' educational achievement in all three domains of observed literacy. The results of the analysis indicate that, on average, an increase in this index by a single unit leads to improvements in mathematical, reading and science literacy of 15, 17, and 16 PISA points respectively.

Similarly, the influence of a large number of variables related to the characteristics of the family in which a student is raised is statistically significant and has a sign in the expected direction. The impact of students' socio-economic background should be highlighted. Measured by the value of the ESCS index, it is positive in all three domains of literacy. Increasing the value of

the ESCS index by a single unit results in improvements in mathematical, reading, and scientific literacy of 23, 21, and 15 PISA points, respectively. These increments correspond to the effect of one-half or one-third of the school year, depending on the observed literacy domain. This suggests that an important determinant of student achievement is a student's socio-economic origin, which means that the Serbian educational system is failing to provide equal access to quality education for students from different socio-economic backgrounds. Furthermore, the average student who lives with both parents or with one parent achieves better results in mathematical, reading, and science literacy of about 27, 31 and 28 PISA points respectively compared to the average student who does not live with parents. However, the impact of parental status in the labour market and parents' education level on educational attainment is positive but almost negligible, since an increment of a single unit in the value of the index only leads to improvements in mathematical, reading, and science literacy of between 1 and 4 PISA points.

The influence of many of the variables relating to the characteristics of the school a student attends is either statistically insignificant or negligible. The result that a student's individual characteristics and the characteristics of the student's family have a bigger effect on educational attainment than the characteristics of the school the student attends is in accordance with a number of other studies that use the model of production function in education (e.g., Hanushek and Luque 2003; Woessmann 2003). Variables such as the type of school and school location have a statistically significant effect on the quality of education. More specifically, the average public school student's academic achievement in mathematical, reading, and scientific literacy was 30, 51, and 41 PISA points better, respectively, than private school students. Similarly, the results of a student who attends an urban school are better in all three domains of literacy by 18 PISA points in comparison to a student who attends a rural school. Fuchs and Woessmann (2007) come up with similar results in terms of the impact of the type of school and school location on the quality of education. Interestingly, in contrast to the positive influence of schools' degree of freedom in defining and implementing the curriculum (measured by the value of the index of school responsibility for the curriculum) the impact of schools' degree of freedom in managing resources (measured by the value of the index of school responsibility for resources) is negative. An increment of one single unit in the value of the index of school responsibility for resources leads, on average, to a deterioration in students' achievement in mathematical, reading, and science literacy by 15, 24, and 21 PISA points respectively. A possible explanation for

this result is that greater freedom for schools in areas where school principles can behave opportunistically, for example, in formulating the school budget, has a negative impact on education quality.

The results obtained by unconditional quantile regression help answer the question of whether the positive effects of attending preschool for more than a year on students' educational achievement in PISA2012 testing are greater in the case of students who achieved the worst results or in the case of students who achieved the best results. A review of the effects of attending preschool for students belonging to the first and the last quartiles of the distribution of educational attainment in terms of mathematical, reading and scientific literacy is presented in Tables A3, A4, and A5 respectively. These results suggest that the sign and intensity of the effect of more than a year of preschool education are positive and increasing. In other words, when students' educational achievement in mathematical, reading, and science literacy is better the effect of preschool programmes is greater. The unconditional quantile regression results are more directly interpretable than the weighted least square regression results since they suggest that the effect of preschool education is heterogeneous and stronger for the best students. For example, in the case of students who belong to the first quartile of the distribution of educational attainment in terms of mathematical literacy, the effect of attending preschool for more than a year is 10 PISA points, while in the case of students who belong to the last quartile of the distribution of educational attainment it is 22 PISA points. Similarly, if we look at the distribution of educational attainment in terms of reading literacy, the impact of students from the first quartile attending preschool programmes for more than a year equals 11 PISA points, while for students who belong to the last quartile it is 21 PISA points. In terms of scientific literacy, the effect of students from the first quartile in the distribution of educational attainment attending preschool for more than a year is 10 PISA points, while for students who belong to the last quartile it is 20 PISA points. This difference between students who belong to the first and the last quartiles of the distribution of educational attainment in the effect of attending preschool for more than a year ranges between 10 and 12 PISA points, depending on the domain of literacy, and corresponds to the effect of slightly more than a quarter of the school year. Thus, the effect of preschool education is significant in terms of the quality of education of students who belong to different parts of the distribution of educational attainment, and these heterogeneous and increasing effects are of particular importance to those students who achieved the best results in the PISA2012 testing.

It is worth mentioning that the effect of the control variables corresponding to a student's personal characteristics, family characteristics, and characteristics of the school the student attends are mostly statistically significant with the sign in the expected direction. A detailed review of the impact of these variables is provided in Tables A3, A4, and A5 in the Appendix.

Given that the analysis identifies a statistically significant positive and increasing impact of attending preschool education for more than a year on the educational achievements of students in all three domains of literacy in PISA2012 testing, it is necessary to analyse which factors determine whether Serbian children are included in the preschool programme for more than a year. Table A6 presents the results of this analysis obtained using the probit model. The probit model is based on cumulative normal probability distribution, and therefore the coefficients of the probit model are the effects of the probability that the response variable equals one in a cumulative normal function. It should be noted that interpretation of the coefficients in probit regression is not as straightforward as the interpretation of coefficients in weighted least squares regression or unconditional quantile regression. It differs from linear regression, where the estimated coefficients are interpreted directly, because in linear regression the regression coefficients are marginal effects. In probit regression the increase in probability attributed to a one unit increase in a given predictor is dependent both on the values of the other predictors and the starting value of the given predictors. In probit regression an additional step of computation is required to get the marginal effects once the probit regression coefficients have been computed. A positive coefficient only means that an increase in the predictor leads to an increase in the predicted probability, while a negative coefficient only means that an increase in the predictor leads to a decrease in the predicted probability. Therefore, we had to calculate the marginal effects of a change in the predictor on a change in the probability of the response variable to estimate the mean of the partial effects and the partial effects at the mean (Asteriou and Hall 2011); i.e., how much the conditional probability of the response variable changes when the value of a predictor is changed, holding all other predictors constant at some values.

The results of the probit regression show that the factors that determine whether a child will attend preschool education for more than a year are the child's socio-economic family background, measured by the value of the ESCS index, and parental status in the labour market. On average, reducing the value of this index by a single unit results in a reduction in the probability that the

child will attend preschool education by 11 percentage points. In other words, students who come from socio-economically disadvantaged families are less likely to be covered by the preschool programme for more than a year. If the mother is unemployed or inactive in the labour market (e.g., retired, home duties) it reduces the likelihood that the child will attend preschool education by 15 and 13 percentage points compared to students whose mothers work full-time. If the father is unemployed or inactive in the labour market (e.g., retired, home duties) it reduces the probability that the child will attend preschool by 5 and 9 percentage points compared to children whose fathers are employed full-time. It should be noted that the impact of variables related to parental educational level is not statistically significant. These results are consistent with many other studies (e.g., Wrohlich 2004; Barnett 2008; Anders et al. 2012). As preschool institutions have limited capacity it is expected that children of parents who work full-time will be prioritized, so the coverage of children of employed parents is greater than the coverage of children whose parents are unemployed or inactive in the labour market. But these results are worrying, because children whose parents work full-time are probably children who come from socio-economically advantaged families. In other words, the current system is ineffective in providing children from socio-economically disadvantaged families with preschool education because it has insufficient coverage. This is particularly disturbing if we consider the results that show the importance of attending preschool for more than a year for academic achievement, especially for those students who achieved the best results in the PISA testing. Children whose parents are unemployed or inactive and who come from socio-economically disadvantaged families are less likely to attend preschool for more than a year and therefore do worse academically. Because the quality of education has a direct effect on labour market outcomes, it can be assumed that these children will have worse jobs, or even be unemployed. Therefore, the results of this analysis indicate that the Serbian educational system reproduces poverty and social exclusion.

6. CONCLUSION

A large body of research from variety of economic disciplines demonstrates that early childhood education and care provides the foundation for later academic and social success. Both can accelerate economic growth and promote more equal opportunity over time. Preschool education is an important step in preparing children for future education, which could have a far-reaching effect on their chances in life. This is especially true of children from socio-

economically disadvantaged backgrounds, who receive less early learning support than children from advantaged families, Preschool education is recognized as an essential factor in solving the problems of poverty and social exclusion because it prepares children to enter the educational system and leads to better educational attainment and easier social integration.

This paper examines the effect of preschool education on students' educational attainment and factors that influence whether a child is included in the Serbian preschool programme. The analysis is based on data from PISA2012 testing. We used weighted least squares regression and unconditional quantile regression to assess the significance and nature of the effect of preschool education on educational attainment in terms of mathematical, reading, and scientific literacy. Weighted least squares regression enabled us to estimate the average effects of attending the preschool education programme on the academic attainments of students, while unconditional quantile regression allowed us to determine whether these effects are different for students in various parts of the distribution of educational achievement; i.e., whether these effects are increasing or decreasing. We also applied probit regression to analyse the factors that affect whether a child is included in the preschool programme.

The results of the weighted least squares regression indicate that the effects of attending preschool education for more than a year are statistically significant and positive. On average, a student who attended the preschool programme for more than a year achieved levels of mathematical, reading, and science literacy that are 17, 15, and 14 PISA points better, respectively, than those of a student who has not attended preschool. The impact of most variables related to students' individual characteristics is statistically significant and has a sign in the expected direction. Similarly, the influence of a large number of the variables relating to the characteristics of the family in which a student is raised is statistically significant and has a sign in the expected direction. However, the influence of the variables relating to the characteristics of the school a student attends is either statistically insignificant or unimportant.

The unconditional quantile regression results suggest that the sign and intensity of the effects of attending preschool education for more than a year are positive and increasing. In other words, the better a student's educational achievement in mathematical, reading, and science literacy, the greater the effect of the preschool programme. This suggests that the effects of preschool education are heterogeneous and stronger for those students who achieved the best results in

the PISA2012 testing. The effects of the control variables corresponding to the individual student's characteristics, the family characteristics of the student, and the characteristics of the school the student attends are mostly statistically significant with the sign in the expected direction.

The results of the probit regression show that socio-economic family background and parental status in the labour market are the factors that determine whether a child will attend preschool education for more than a year. On average, reducing the value of the ESCS index by a single unit results in a reduction in the probability that the child will attend preschool of 11 percentage points. If the mother is unemployed or inactive in the labour market it reduces the probability that the child will attend preschool education by 15 and 13 percentage points compared to students whose mothers work full-time. If the father is unemployed or inactive in the labour market it reduces the probability that the child will attend preschool by 5 and 9 percentage points compared to students whose fathers are employed full-time. In other words, the current system of preschool provision in Serbia is failing children from socio-economically disadvantaged families because insufficient capacity means that children from these families are excluded.

Thus, the main barrier to more children receiving preschool education in Serbia, especially children from disadvantaged backgrounds, is the inadequate network of preschool institutions. Although the National Millennium Development Goals in the Republic of Serbia (2006) stipulated that the number of preschool institutions in Serbia should be doubled by 2015, between 2006 and 2016 the number only increased by 40%. Therefore, in order to include more children from the poorest families whose parents are unemployed or inactive in the labour market, the number of preschool institutions in Serbia needs to be increased.

However, there are other reasons for the low coverage of children from socioeconomically vulnerable families besides the lack of physical capacity, such as parental misunderstanding of the importance of preschool education to their child's development. A large number of studies show that parents whose children do not attend preschool believe that there is no need for it. In most cases less-educated parents do not recognize the value of attending preschool programmes. Therefore, parents in Serbia need to be better informed and educated on the benefits of preschool education.

Given the close link between preschool education and parental employment, improving employment opportunities and encouraging paid work among mothers and fathers with lower socio-economic status would help increase the demand for preschool programmes among socio-economically disadvantaged families. This requires a labour market environment that allows families with limited resources to combine work with caring responsibilities. It also means ensuring that work pays for the parents of young children, especially for those on low wages, because high tax rates mean that work incentives for low-paid parents are weak. Reducing participation tax rates in Serbia, either by cutting out-of-pocket childcare costs for the poorest families or by reducing the tax burden for low-paid parents, would encourage employment among currently unemployed or inactive mothers and fathers with young children and in turn increase the chances of their children attending preschool programmes.

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APPENDIX

Table A1: Description of the variables and summary statistics

Variable	Description	Min	Max	Mean	Std. Dev.
Educational Attainment (EA)					
Mathematics Score	Mathematics literacy attainment	105,32	766.01	448.86	1.43
Reading Score	Reading literacy attainment	98.62	777.16	446.13	1,53
Science Score	Science literacy attainment	157.16	742.02	444.80	1.44
Preschool Education (PE)					
Preschool Education – Less One Year	Student attended preschool education less than one year or not at all	0	1	0.49	0.50
Preschool Education – More One Year	Student attended preschool education for more than one year	0	1	0.51	0.50
Personal Characteristics (PC)					
Gender – Female	Student is female	0	1	0.51	0.50
Gender – Male	Student is male	0	1	0.49	0.50
Age	Age	15.33	16.33	15.86	0.28
Grade	Grade	7	10	9.01	0.15
ANCATSCHL	Index of student's attitude towards school				
Family Characteristics (FC)					
ESCS	Index of economic, social, and cultural status	-3.05	2.52	-0.30	0.89
Family Structure – Both Parents	Student lives with both parents	0	1	0.90	0.30
Family Structure – Single Parent	Student lives with one parent	0	1	0.09	0.28
Family Structure – Other	Student does not live with parents (e.g.. with cousin)	0	1	0.01	0.11
HISEI	Index of parental occupation status	11.01	88.96	46.40	20.59
PARED	Index of highest parental education level	3	17	13.47	2.75
Parents' Education Level (PEL)					
Mother Education – No Primary	Mother did not finish primary education	0	1	0.01	0.09
Mother Education – Primary	Mother finished primary education	0	1	0.10	0.30
Mother Education – Secondary	Mother finished secondary education	0	1	0.40	0.49
Mother Education – Post-Secondary	Mother finished post-secondary education	0	1	0.04	0.20
Mother Education – Tertiary	Mother finished tertiary education	0	1	0.26	0.44
Mother Education – Post-Tertiary	Mother finished post-tertiary education	0	1	0.19	0.39
Father Education – No Primary	Father did not finish primary education	0	1	0.01	0.09
Father Education – Primary	Father finished primary education	0	1	0.08	0.27
Father Education – Secondary	Father finished secondary education	0	1	0.44	0.49

Father Education – Post-Secondary	Father finished post-secondary education	0	1	0.03	0.16
Father Education – Tertiary	Father finished tertiary education	0	1	0.26	0.44
Father Education – Post-Tertiary	Father finished post-tertiary education	0	1	0.18	0.39
Parents' Labour Status (PLS)					
Mother Labour Status – Employed Full-Time	Mother is employed full-time	0	1	0.55	0.50
Mother Labour Status – Employed Part-Time	Mother is employed part-time	0	1	0.04	0.20
Mother Labour Status – Unemployed	Mother is unemployed	0	1	0.18	0.39
Mother Labour Status – Other	Mother is inactive (e.g., retired. home duties)	0	1	0.23	0.41
Father Labour Status – Employed Full-Time	Father is employed full-time	0	1	0.69	0.46
Father Labour Status – Employed Part-Time	Father is employed part-time	0	1	0.08	0.27
Father Labour Status – Unemployed	Father is unemployed	0	1	0.11	0.31
Father Labour Status – Other	Father is inactive (e.g., retired. home duties)	0	1	0.12	0.2
School Characteristics (SC)					
School Type – Public	School is public	0	1	0.99	0.06
School Type – Private	School is private	0	1	0.01	0.06
School Location – Urban	School is urban	0	1	0.41	0.49
School Location – Rural	School is rural	0	1	0.59	0.49
School Size	School size	19	2.184	733.93	352.29
Class Size	Average class size in school	13	53	27.81	6.20
RESPCUR	Index of school responsibility for curriculum	-1.26	0.03	-0.86	0.21
RESPRES	Index of school responsibility for resources	-0.77	2.71	-0.40	0.29
SCMATBUI	Quality of school physical infrastructure index	-2.75	1.31	-0.33	0.94
SCMATEDU	Quality of school educational resources index	-0.57	0.86	-3.59	1.97
Number of observations	4,684				

Source: Authors' calculation

Table A2: Weighted least squares regression estimation results

Variable	**Coefficient**		
Educational Attainment (EA)	**Mathematics Score**	**Reading Score**	**Science Score**
Preschool Education (PE)			
Preschool Education – More One Year	**16.87 (3.06)***	**14.97 (3.11)***	**14.25 (3.28)***
Personal Characteristics (PC)			
Gender – Male	11.04 (2.75)*	-23.15 (2.76)*	-9.41 (2.80)*
Age	4.16 (4.85)	0.93 (5.17)	8.81 (4.87)***
Grade	28.64 (10.19)*	23.62 (11.18)**	11.07 (11.12)
ANCATSCHL	14.96 (1.81)*	16.94 (2.19)*	15.75 (2.05)*
Family Characteristics (FC)			
ESCS	23.08 (4.86)*	21.15 (5.81)*	14.16 (5.34)*
Family Structure – Both Parents	27.20 (14.06)**	32.31 (14.19)**	28.52 (15.19)***
Family Structure – Single Parent	26.63 (14.77)***	31.02 (14.99)**	27.21 (16.36)***
HISEI	0.62 (0.13)*	0.56 (0.15)*	0.64 (0.13)*
PARED	4.78 (1.01)*	4.01 (1.21)*	2.75 (1.16)**
School Characteristics (SC)			
School Type – Public	30.19 (28.52)*	50.44 (31.48)*	41.30 (31.24)*
School Location – Urban	18.96 (3.30)*	17.77 (3.64)*	18.11 (3.07)*
School Size	0.01 (0.01)*	0.01 (0.00)***	0.01 (0.01)*
Class Size	0.33 (0.23)	0.40 (0.24)	0.19 (0.23)
RESPCUR	10.42 (6.18)**	7.36 (6.10)*	12.89 (6.36)*
RESPRES	-14.97 (6.74)*	-24.30 (6.70)*	-20.68 (7.23)*
SCMATBUI	1.49 (1.66)	1.41 (1.87)*	1.94 (1.68)
SCMATEDU	4.49 (1.87)*	6.71 (2.14)	3.56 (1.86)**
Constant	85.45 (113.49)	148.11 (129.41)	131.69 (118.54)
R^2 adjusted	0.26	0.29	0.23

Source: Authors′ calculations

Table A3: Unconditional quantile regression estimation results (Mathematics Literacy Attainment)

Variable	**Coefficient**	
Educational Attainment (EA)	**Mathematics Score**	
Preschool Education (PE)	First quartile (0.25 quantile)	Last quartile (0.75 quantile)
Preschool Education – More One Year	**10.35 (4.03) ***	**22.05 (5.43)***
Personal Characteristics (PC)		
Gender – Male	10.08 (4.54)**	10.97 (5.32)**
Age	3.46 (7.33)	6.20 (7.92)
Grade	19.09 (15.18)	37.99 (21.74)***
ANCATSCHL	12.5 (2.63)*	17.01 (3.14)*
Family Characteristics (FC)		
ESCS	24.84 (7.53)*	26.14 (8.33)*
Family Structure – Both Parents	29.07 (22.94)	8.03 (22.70)
Family Structure – Single Parent	30.01 (22.66)	10.65 (23.86)
HISEI	0.47 (0.20)**	0.76 (0.29)**
PARED	5.23 (1.57)*	4.20 (1.53)*
School Characteristics (SC)		
School Type – Public	42.37 (40.46)	31.35 (57.71)
School Location – Urban	8.90 (5.34)***	24.42 (4.87)*
School Size	0.02 (0.01)	0.01 (0.01)
Class Size	0.53 (0.46)	0.37 (0.33)
RESPCUR	13.29 (8.56)	11.42 (10.66)
RESPRES	-25.0 (8.86)*	-12.83 (12.41)*
SCMATBUI	2.73 (2.49)	4.93 (3.12)
SCMATEDU	7.96 (3.08)*	10.79 (3.83)*
Constant	129.27 (178.95)	18.41 (247.91)
R^2 adjusted	0.17	0.21

Source: Authors' calculations

Table A4: Unconditional quantile regression estimation results (Reading Literacy Attainment)

Variable	**Coefficient**	
Educational Attainment (EA)	**Reading Score**	
Preschool Education (PE)	First quartile (0.25 quantile)	Last quartile (0.75 quantile)
Preschool Education – More One Year	**11.73 (4.34)***	**20.97 (5.62)****
Personal Characteristics (PC)		
Gender – Male	-47.77 (4.94)*	-39.17 (4.94)*
Age	5.32 (7.42)	3.46 (9.10)
Grade	17.70 (15.36)	21.53 (18.90)
ANCATSCHL	19.43 (3.20)*	15.62 (2.90)*
Family Characteristics (FC)		
ESCS	19.83 (8.97)**	24.21 (7.38)*
Family Structure – Both Parents	33.43 (21.58)	13.37 (19.23)
Family Structure – Single Parent	27.38 (23.12)	16.08 (20.97)
HISEI	0.56 (0.22)*	0.68 (0.24)*
PARED	4.42 (1.83)**	3.67 (1.71)**
School Characteristics (SC)		
School Type – Public	98.35 (55.38)***	52.62 (45.65)
School Location – Urban	12.09 (6.24)***	16.04 (6.02)*
School Size	0.01 (0.01)	0.02 (0.01)
Class Size	1.06 (0.33)*	1.17 (0.42)
RESPCUR	12.43 (10.48)	4.91 (9.10)
RESPRES	-13.21 (9.13)*	-9.55 (9.81)*
SCMATBUI	4.77 (2.52)**	0.83 (2.78)
SCMATEDU	11.23 (2.69)*	9.26 (2.84)*
Constant	56.56 (194.43)	215.50 (204.92)
R^2 adjusted	0.20	0.21

Source: Authors' calculations

Table A5: Unconditional quantile regression estimation results (Science Literacy Attainment)

Variable	**Coefficient**	
Educational Attainment (EA)	**Science Score**	
Preschool Education (PE)	First quartile (0.25 quantile)	Last quartile (0.75 quantile)
Preschool Education – More One Year	**10.36 (4.08)***	**20.06 (4.84)****
Personal Characteristics (PC)		
Gender – Male	-7.13 (4.21)***	-1.06 (4.14)
Age	11.12 (7.15)	7.84 (8.40)
Grade	3.94 (13.07)	10.25 (15.72)
ANCATSCHL	15.08 (2.98)*	17.92 (3.06)*
Family Characteristics (FC)		
ESCS	14.53 (9.14)***	18.53 (7.97)**
Family Structure – Both Parents	22.32 (21.39)	4.883 (18.46)
Family Structure – Single Parent	29.54 (22.76)	13.46 (20.43)
HISEI	0.58 (0.24)**	0.75 (0.23)*
PARED	3.63 (2.20)	2.71 (1.61)***
School Characteristics (SC)		
School Type – Public	93.36 (48.42)***	63.61 (67.62)
School Location – Urban	15.42 (4.93)*	17.01 (6.19)*
School Size	0.01 (0.00)	0.01 (0.01)**
Class Size	0.46 (0.38)	0.08 (0.38)
RESPCUR	22.88 (10.15)**	10.79 (10.62)
RESPRES	-19.77 (11.50)*	-20.47 (15.44)*
SCMATBUI	5.70 (2.71)**	1.49 (2.64)
SCMATEDU	9.96 (2.95)*	5.52 (2.73)**
Constant	93.73 (170.53)	212.80 (187.87)
R^2adjusted	0.16	0.19

Source: Authors′ calculations

Table A6: Probit regression estimation results

Variable		
Preschool Education (PE)	**Coefficient**	**Marginal effects**
ESCS	0.31 (0.04)*	**0.11 (0.01)***
Parents Education Level (PEL)		
Mother Education – Primary	-0.41 (0.30)	-0.14 (0.11)
Mother Education – Secondary	-0.24 (0.30)	-0.08 (0.11)
Mother Education – Post-Secondary	-0.06 (0.31)	-0.02 (0.11)
Mother Education – Tertiary	-0.21 (0.30)	-0.07 (0.11)
Mother Education – Post-Tertiary	-0.22 (0.31)	-0.08 (0.11)
Father Education – Primary	0.63 (0.33)	0.23 (0.12)
Father Education – Secondary	0.46 (0.32)	0.17 (0.12)
Father Education – Post-Secondary	0.24 (0.34)	0.09 (0.12)
Father Education – Tertiary	0.36 (0.33)	0.13 (0.12)
Father Education – Post-Tertiary	0.38 (0.33)	0.14 (0.12)
Parents Labour Status (PLS)		
Mother Labour Status – Employed Part-Time	0.12 (0.10)	0.04 (0.03)
Mother Labour Status – Unemployed	-0.31 (0.05)*	**-0.15 (0.02)***
Mother Labour Status – Other	-0.37 (0.05)*	**-0.13 (0.01)***
Father Labour Status – Employed Part-Time	0.05 (0.07)	0.02 (0.02)
Father Labour Status – Unemployed	-0.06 (0.06)**	**-0.05 (0.02)****
Father Labour Status – Other	-0.14 (0.06)**	**-0.09 (0.02)****
Constant	0.07 (0.36)	
Pseudo R^2	0.16	

Source: Authors' calculations

Remarks:

(1) Robust standard errors in parentheses;
(2) Statistically significant at 0.01 level (*);
(3) Statistically significant at 0.05 level (**);
(4) Statistically significant at 0.10 level (***).