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Determining children's cognitive abilities and relationship to economic outcomes in adolescence

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Abstract

Purpose — This study examines the determinants of cognitive abilities among school-age children in Indonesia and their effects on subsequent educational attainment and labor market outcomes.
Methods — The study uses longitudinal data from the Indonesian Family Life Survey (IFLS) for 2000 and 2014. Ordinary Least Squares (OLS) is employed to identify the determinants of cognitive abilities, while Instrumental Variable–Two-Stage Least Squares (IV-2SLS) is used to estimate their effects on education and wages.
Findings — Children's cognitive abilities are influenced by parental education, parental psychological health, residential location, educational expenditure, and birth order. Higher childhood cognitive scores are associated with greater educational attainment and higher wages later in life.
Implications — Policies aimed at improving children's cognitive development should strengthen family socioeconomic conditions, parental well-being, educational investment, and support for children in disadvantaged areas.
Originality — This study provides longitudinal evidence from Indonesia linking childhood cognitive abilities with later educational and labor market outcomes. It also applies an IV-2SLS approach to address potential endogeneity and produce more robust estimates.
Keywords: Cognitive Ability, Educational Achievement, Wages, OLS, IV-2SLS
JEL Classification: I21; J24; J31; J13

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Introduction

Education plays an essential role in the development of children and children's lives in the future. Parisi et al. (2012) stated that education could foster knowledge, abilities, and intellectual skills such as reading, speed of thinking, etc. Individuals with high levels of educational attainment are associated with reasonably good cognitive skills. Finnie, Lascelles, and Sweetman (2005) stated that education level is essential for an individual career and economic success. Higher education becomes an opportunity for individuals to get a better job and income. On the other hand, education measured through academic achievement is also determined by the socio-economic characteristics of the family and social, environmental factors (Tomul and Polat, 2013).

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Woessmann (2004) used the Third International Mathematics and Science Study (TIMSS) as a cognitive measure to estimate the impact of parental education and other family background measures on standard achievement test scores in mathematics and science. TIMSS contains academic achievement data for a representative sample of secondary school students in Western Europe (15 countries) and the United States. Woessmann (2004) shows a powerful influence between family background and students' cognitive abilities. The level of parental education correlates positively with student achievement in all European countries and the United States. Another family characteristic, namely students who still live with both parents, is statistically positively correlated with student learning outcomes.

Usaini and Abubakar (2015) analyzed the relationship between the employment status (formal and informal) of students' parents on students' academic performance in Malaysia. The study results showed that students whose parents worked in the formal sector had better academic achievements or achievements than students whose parents worked in the informal sector. Parents who work in the formal sector have a stable income to support their children's education costs. On the other hand, parents who work in the informal sector mostly do not have sufficient income to pay for their children's education. It shows that the socioeconomic background in the form of family income is an essential factor in determining student academic achievement.

The variable used in this study is the variable cognitive abilities of children in elementary education. The use of cognitive abilities as a variable to be studied is based on several studies. Blau (1999) and Tesfagiorgis et al. (2020) state that cognitive abilities are influenced by the socioeconomic background of the family, such as education level, parents' income, and household size. Cognitive abilities in childhood and adolescence have also been used to predict success in adulthood. This success is in educational attainment, income, and employment (Cawley et al. 2001; Heckman et al. 2006; Lindqvist and Vestman, 2011).

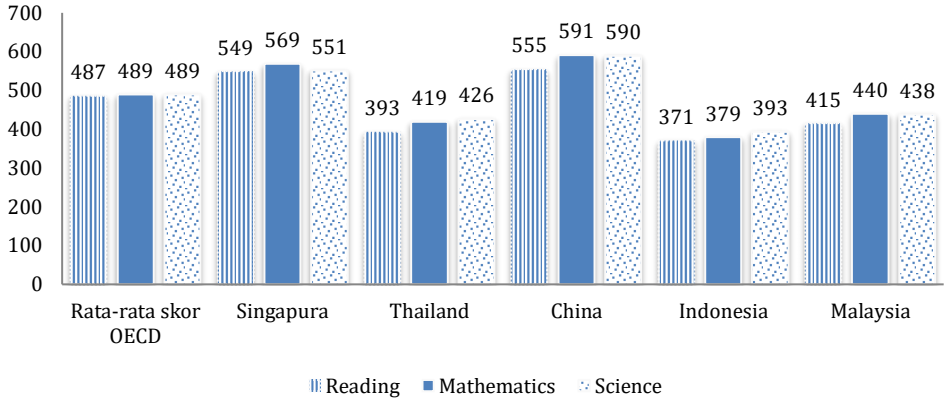
Cawley et al. (2001) stated that cognitive ability is a strong predictor of school achievement and wages. Cognitive abilities explain most of the differences in wages between individuals. The analysis found that cognitive ability is associated with wage levels, between 2.7 percent of wage variations by controlling for measures of human capital, such as education and work experience. Cognitive abilities can increase worker productivity and directly affect wages (Heckman et al, 2006). Several empirical studies also support the results of these studies and have confirmed the positive effects of cognitive abilities on wages (Adhitya et al. 2019; Acosta et al. 2020). Adhitya et al. (2019) examined the effect of cognitive abilities on labor market outcomes in Indonesia. The study tested the Mincer equation for the determinant of wages using the OLS method. The results of his research indicate that cognitive abilities have a positive and significant relationship with monthly salaries. Acosta et al. (2020) reported that individuals with higher cognitive abilities have better jobs and higher income.

Anger and Heineck (2010) focused on analyzing the relationship between cognitive abilities (cognitive test scores) and workers' income in Germany. Their study found that cognitive abilities were positively correlated with wage levels. Another study by Murnane, Willett, and Levy (1995) used longitudinal survey data of American high school students to analyze the relationship between cognitive ability and income. The study results show that cognitive abilities as measured by math scores have a positive and significant relationship with wages by controlling for

aspects of family background, including the number of siblings, family status with single parents, and the educational attainment of fathers and mothers.

Morris, Dorling, and Davey Smith (2016) used the Wechsler Intelligence Scale for Children (WISC) to analyze the relationship between cognitive abilities and educational attainment in the UK. The results of his study found that cognitive skills as measured by WISC predicted educational outcomes very well. Children's cognitive skills at the age of eight showed a linear pattern with their educational attainment at the age of 16. The study of Morris et al. (2016) also looked at the extent to which variations in cognitive abilities explained socioeconomic disparities in education. Highly able children who come from low socioeconomic backgrounds tend to reduce their academic potential in school.The figure below presents a comparison of the PISA scores of primary school children in several ASIA countries.

Figure 1. PISA Score of Several Countries in ASIA



Source: OECD, (2019)

Figure 1 shows that Indonesia's cognitive capacity is still low. Students' ability is still below the average international standard, as evidenced by the results of the 2018 PISA, namely Indonesia ranked 73 out of 79 countries (OECD, 2019). Indonesia's performance among other Asian countries in literacy, mathematics, and science is still far behind China, Singapore, and Malaysia. The PISA score obtained from each country depends on the quality and equality of learning outcomes that have been achieved around the world.

Based on BPS data in 2018, it shows that the population aged 15 years and over who have entered the labor market, the majority have an elementary school (SD) graduate level. When broken down by education level, 25.21 percent of Indonesian workers only graduated from elementary school, followed by 18 percent who graduated from junior high school (SLTP). It shows that workers in Indonesia of this age are dominated by unskill labor. It shows cognitive abilities to increase individual capacity and is an essential part of human resource development (Zahra dan Wisana, 2019). Therefore, families and policymakers also need to pay more attention and implement various strategies to improve the cognitive abilities of school-age children so that future generations will be more productive and competitive.

Based on the background described, most studies only analyze the effect of children's cognitive abilities on educational attainment and the labor market. These

studies have not been equipped with analyses of the determinants of cognitive abilities. Studies examining childhood cognitive abilities (children) and their impact on educational outcomes and the labor market in Indonesia are also limited. It is what motivates the author to be interested in researching cognitive abilities in Indonesia. This study will add to the analysis of the determinants of cognitive abilities in childhood and the consequences of cognitive abilities on educational attainment and outcomes in the labor market after the individual is an adult.

This study aims to analyze the determinants of cognitive abilities and their effect on educational outcomes measured by educational attainment (length of school) and labor market outcomes in Indonesia as measured by wages. This study uses longitudinal data from IFLS for two waves, namely in 2000 and 2014. The two waves of data were chosen because, in 2000, individuals had school status and had done cognitive tests at the age of 7-14 years. Furthermore, in 2014 the individual is estimated to have reached adolescence or adulthood so that this data can see educational outcomes in the form of academic attainments and individual achievements in the labor market. This study uses the OLS and Instrumental Variable (IV) methods. The OLS method is used to estimate the determinants of cognitive abilities. In contrast, the Variable Instrumental method is used to estimate the effect of cognitive abilities on educational attainment (length of school) and labor market outcomes (wages).

The paper's novelty is substantive and longitudinal rather than based on a new estimator. Its main contribution is to connect the formation of cognitive skills in childhood with educational and wage outcomes fourteen years later in a single Indonesian panel. The analysis also brings parental psychological well-being, educational expenditure, birth order, and rural–urban location into the same framework and explicitly treats parental education as a socioeconomic/human-capital measure, not as evidence of genetic inheritance. This life-course framing provides policy-relevant evidence on where interventions may be most effective before labor-market inequalities become entrenched.

The systematics of writing in this study include: Introduction contains a background in the form of issues that occurred, objectives, and a summary of research methods, as well as systematics of writing. Literature review explains the theoretical basis, the results of previous research, and the hypotheses in the study. Methodology contains the types and sources of data, empirical models, definitions of operational variables, and analytical techniques. Discussions explains the general description of the research object, the analysis model and research results, as well as hypothesis testing. Conclusion contains conclusions and suggestions, as well as research limitations.

Cognitive abilities are very general mental abilities and include, among others: reasoning abilities; solving a problem; plan; abstract thinking and understanding complex ideas; learn quickly; learn from experience. Cognitive abilities are also reflected by the following: the broader ability to understand, capture, and determine what to do (Gottfredson, 1997).

Huitt and Hummel (2003) explain Piaget's opinion, which identifies four stages in cognitive development as follows. First, the sensorimotor stage (infancy) is the stage of intelligence shown through motor activity or movement. Children acquire fixed objects (memory) at about seven months of age. On the other hand, children begin to develop intellectual abilities when physical development and some language skills are also produced at the end of this stage. Second, the pre-operational stage (infancy), the stage of intelligence shown by using symbols, children's language becomes more mature, and memory and imagination are more developed. Third, the

concrete operational stage (early adolescence), namely the stage of intelligence shown through logical and systemic thinking of symbols related to concrete objects. Though that judges everything from its point of view diminishes. Fourth, the formal operational stage occurs in adolescence and adulthood, in which the intelligence stage is shown in the use of symbols related to abstract concepts logically. At this stage, many individuals do not think formally as adults.

Sternberg and Sternberg (2012) state that several cognitive models explain individual intelligence. One such intelligence model is Carroll's (1993) model known as the "Three-Stratum Model of Intelligence." Stratum One includes specific and specialized abilities such as spelling abilities and reasoning speed. Stratum two consists of a broader range of capabilities, such as fluid intelligence, crystallized intelligence, long-term storage and retrieval, and information processing speed. Stratum three covers general intelligence. Of the various stratums, the most interesting is the middle stratum, whose coverage is not too narrow and broad. The middle stratum consists of fluid abilities and crystallized abilities. Fluid abilities are logical and accuracy abilities that are used to solve new problems. On the other hand, crystallized abilities are abilities that are demonstrated through general knowledge and vocabulary.

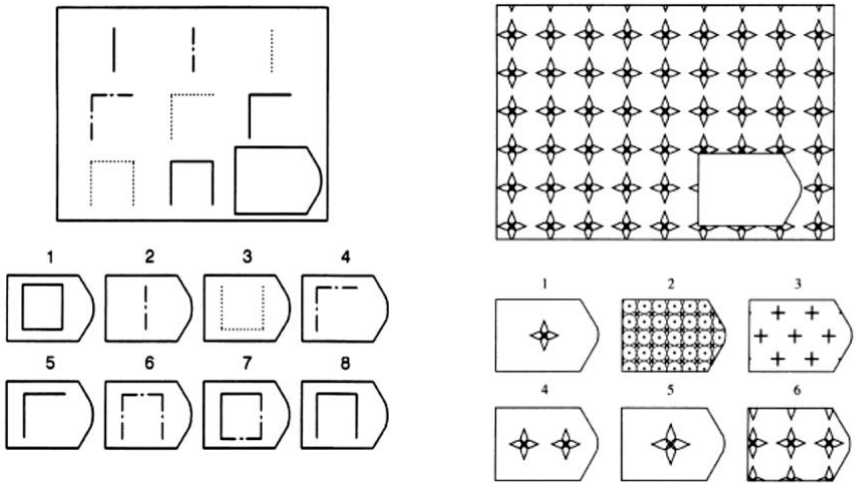
In Indonesia, there is a cognitive assessment or measurement that is carried out regularly (Asrijanty, 2020). The assessment aims to check students' basic abilities in a particular topic or subject. Cognitive assessments can be carried out periodically after the teacher has finished discussing the issue or are carried out per semester. Student cognitive assessment consists of three stages, namely preparation, implementation, examination and follow-up. The preparation stage includes the following steps: planning for carrying out the assessment, identify assessment materials and compiling 10 (ten) questions. At the implementation stage, students are given questions to work on in class face-to-face and at home. The final stage includes examination and follow-up. Self-examination comprises several steps, including (1) Conducting an assessment for each student, giving a grade of one if the answer is correct and zero if it is wrong. (2) Based on the results of the assessment, students were divided into three groups. First, students with grades above average are still taught by the class teacher. Second, students with grades below average for one semester will receive additional lessons. Third, students with scores below the average for two semesters will be made by the study group teacher, accompanied by their parents. (3) Repeating the same process until students can achieve the expected competencies.

Here are some of the measurements used in international studies of cognitive ability about PISA is a program organized by the Organization for Economic Cooperation and Development (OECD). PISA is an international assessment system on cognitive performance that focuses on the abilities of children aged 15 (fifteen) years. OECD (2021) presents three PISA measurement indicators: (1) Reading performance measures the capacity to understand, use, and reflect written text to develop knowledge, potential, and participate in society. (2) Mathematics performance measures children's mathematical literacy to formulate and interpret mathematics in describing, predicting, and explaining phenomena. (3) Science performance measures children's scientific literacy to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about problems related to science.

Raven's Progressive Matrices (RPM) test is a nonverbal test that is usually used to measure individual cognitive abilities in general (John dan Raven, 2003). RPM consists of three types of tests for different individuals. First, Standard Progressive

Matrices (SPM) is one of the most basic tests given to groups and individuals from 5 (five) years of age to the parents and consists of five sets of items from the form of questions shown in Figure 2 With each set, the item becomes increasingly difficult.

Figure 2. Standard Progressive Matrices Test Items



a. Easy b. Harder

Source: John and Raven (2003)

Second, Colored Progressive Matrices (CPM) is designed for children ages five to eleven, the elderly, and individuals with mental disorders. CPM contains 36 issue items presented in different colors, but almost the same as SPM. Finally, Advanced Progressive Matrices (APM) consists of 48 items similar to SPM but much more difficult. This test is intended for children aged eleven and over with above-average intellectual abilities.

Each Raven's Progressive Matrices (RPM) test only produces one score for each item answered correctly (Domino & Domino, L., 2006). A raw score will be obtained from each correct item, which is then converted into a percentile (Lukman, 2013). Nur'aeni (2012) states that individual IQ cannot be found in this test, but the level of intelligence is divided into levels of one to five, which are determined based on percentiles.

The family socioeconomic background variables used in this study were income, education, and parents' psychological health. Mayer (2002) states that the relationship between parental income and children's cognitive test scores results from the inability of parents who have low income, which causes them to feel anxious, depressed, and ultimately can reduce their ability to support children in improving their abilities. Mayer (2002) argues that there are other factors, one of which is genetic. Physically tall parents tend to have tall children. The same is true of academic performance. People with high education and good academic performance will tend to pass on to their children.

The socioeconomic background in parental education is also an essential factor in determining children's cognitive outcomes. Burhan et al. (2017) stated that parents' level of education has a positive influence on children's cognitive abilities.

Parents who have higher educational attainment will also have a more heightened awareness of the quality of life, which indirectly improves their children's cognitive abilities. Wang et al. (2020) used a Chinese education panel survey to estimate the effect of parental education on children's academic performance. The results of the study found that parental education plays a positive role in children's academic performance. Highly educated parents tend to have high educational expectations for their children.

Black, Devereux, and Salvanes (2009) focused on estimating the intergenerational transmission of IQ scores. Black, Devereux, and Salvanes (2009) study entitled "Like father, like son? A note on the intergenerational transmission of IQ scores" shows that there are hereditary factors of parental intelligence that will be passed on to their children. The study results found a 10 percent increase in Father's IQ increased 3.2 percent of son's IQ. In this case, there is a similar trend from generation to generation.

Mensah and Kiernan (2010) analyzed the impact of the psychological health of parents on children's cognitive development in England. Her study used data from the Millennium Cohort Study, which included 4,781 British families. The method used to estimate the relationship between the psychological health of parents and children's cognitive development is a regression model. Their study showed a negative relationship between the poor mental health of parents with cognitive achievement of children. Parents who experience high psychological stress impact children's cognitive achievement in language and literacy, mathematics, communication, and children's personal development. Le and Nguyen (2017) used data sets from the Longitudinal Survey of Australian Children (LSAC) to estimate the impact of maternal and fathers' health on children's cognitive abilities in Australia. The study results show a positive and statistically significant relationship (at the 5 percent level) between parental health and children's cognitive abilities. In estimating maternal health on children's cognitive abilities as measured by writing and spelling scores, it shows that poor maternal health allows children to have lower test scores.

Based on the literature review, several factors affect cognitive abilities, one of which is birth order. Several empirical studies suggest that social factors such as customs and culture consider the order of the child's birth as one of the factors that influence the educational investment decisions of parents to children. A paternalistic culture generally gives boys more than girls a greater weight of investment. Meanwhile, certain cultures believe that first-order children must have a high level of education in the hope that these children can set an example and help finance the education of their younger siblings when the first child has entered the labor market (Booth and Kee, 2009). Heiland (2009) stated that the average group of firstborn waves of 1979 from the National Longitudinal Survey of Youth (NLSY79) had higher cognitive abilities than children born later. Black et al. (2011) used a large-scale data set on the population of Norway and found that birth order had a negative and significant correlation with cognitive abilities as measured by IQ. Children born earlier have a higher IQ. Black et al. (2011) argue that the eldest child gets special attention from their parents, while children born afterward have to share time with siblings born earlier.

Monfardini and See (2016) also support the results of this study. Monfardini and See (2016) used a sample of children aged 5-8 years from the Child Development Supplement (CDS) to identify the effect of birth order on children's cognitive outcomes. In the study, they found negative results of birth order on cognitive abilities. Children with higher birth orders are generally found to have poor cognitive

abilities, which is also due to parental time allocation mechanisms.

Methodology

Theoretically, the relationship between cognitive abilities and labor market outcomes is based on human capital theory. Human capital (human capital) is the knowledge, skills, and abilities individuals bring to the labor market (Borjas, 2016). Mankiw (2010) states human capital as an accumulated investment in individuals such as education. Human capital H can be written in the production function as follows:

$$Y = AF(K, H, ..) \quad (1)$$

The equation for the production function reflects a positive relationship between human capital and output. In this study, human capital can describe individual cognitive abilities, and the results of the labor market can define the output in the form of wages. Individuals with better cognitive capacity will produce greater output and lead to better labor market outcomes.

Schoon (2010) conducted a study on the relationship between cognitive ability measured at age ten and academic achievement as an adult in the UK. The results of his research prove that there is a positive relationship between cognitive abilities and educational outcomes. Childhood cognitive abilities were measured using verbal and non-verbal tests, and educational outcomes were indicated by age at retirement. For individuals with high cognitive abilities, academic achievement is also achieved at a higher age (Morris et al., 2016).

The Mincer equation models the natural logarithm of wages as a function of years of schooling and the amount of experience in the labor market (Heckman, 2006). The equation of the function is as follows:

$$Log\ Y = \log Y_0 + rS + \beta_1 X + \beta_2 X^2 \quad (2)$$

In the above equation, Y is the wage, Y_0 is the wage rate of individuals with no education and no experience in the labor market, S is the length of schooling, and X is the amount of experience in the labor market (years). In this equation, the length of education is linear with the natural logarithm of wages. It means that higher individual educational attainment will lead to labor market outcomes, namely better wages.

Empirically, several studies show that cognitive abilities positively correlate to labor market outcomes in the form of wages. Heckman et al. (2006) used National Longitudinal Survey of Youth (NLSY79) data in America to analyze the effect of cognitive abilities on labor market outcomes. Cognitive ability becomes an explanatory variable of the labor market results in the form of wages. From the results of his study, it was found that cognitive abilities explain 9 percent of the variants of the natural logarithm of wages. Mitra (2000) stated that cognitive ability after education is an important predictor of wages in all occupations. Mitra (2000) used NLSY data to analyze the effect of cognitive ability on wages of white and blue-collar workers in African-Americans.

The dependent variable used is the natural logarithm of the hourly wage rate and the independent variable in cognitive abilities as measured by math and English test scores, converted into z-scores. The results of the Partner study found a positive

relationship between cognitive abilities and wages. White-collar workers who have a math score of one standard deviation above the mean are associated with increased wages received by up to 12 percent. On the other hand, among blue-collar workers, a standard deviation of above-average math scores is associated with a 6 percent increase in wages.

The background of socioeconomic status plays an important role in children's cognitive abilities. Dahl and Lochner (2012) used the OLS method to study the effect of family income on children's cognitive achievement. Children's cognitive achievement was measured by reading and math scores. The results of his study show that family income has a positive and significant relationship to children's cognitive abilities, as reflected in children's mathematics scores and reading abilities. An increase in family income of $ 1,000 was associated with math test scores and reading about six standard deviations above the average. Kang (2007) estimated the effect of education expenditure on cognitive abilities in South Korea. Education expenses are measured through private tutoring expenses, while cognitive ability is measured by math and language test scores. Using the Instrumental Variable (IV) analysis method, Kang's study found that a 10 percent increase in education expenditure led to a 0.56 increase in test scores.

Chen et al. (2018) investigated the relationship between family socioeconomic status and children's cognitive abilities based on Chinese cultural background. The variable of family socioeconomic status was measured by family income, parental education level, and job prestige. Children's literacy abilities measure cognitive ability variables. The results of his study indicate that the family's socioeconomic status correlates with children's cognitive abilities. The higher the level of education of the parents, the more prestigious the job and the income, the higher the child's cognitive abilities. Chen et al. (2018) also argue that uneducated parents may not have sufficient abilities to guide their children. It can cause difficulties for children to achieve academic achievement.

The low job prestige generally indicates that the wages earned are low, the working hours are long, and the physical work is hard. It makes parents also do not have time to support their children's education. Families with low incomes also make it possible for them not to provide necessities such as a house, study room, computer, books, and others. So it can be concluded that the family's socioeconomic status has a significant role in the academic performance of children.

Other family social backgrounds such as family size and location of residence are also strong predictors of cognitive abilities. Black, Devereux, and Salvanes (2010) used male population data in Norway to analyze the effect of family size on cognitive abilities as measured by IQ. IV estimation using twin births as an exogenous variation found that family size hurt children's cognitive abilities. Alexopoulos (1997) examined differences in cognitive abilities measured by IQ between urban and rural children in Greece. The results of his study show that the scores of children in urban areas are higher than in rural areas. It is due to the influence of the social and school environment. Education in rural areas is worse than in urban areas. Poor road conditions make school hours shorter in rural areas. In addition, there is a tendency for individuals to move from rural areas to cities and those who are intellectually superior tend to leave the village to study at a higher level. It makes academically capable individuals also decline in rural areas.

Hotz and Pantano (2015) analyzed the effect of birth order on cognitive abilities in America. They used the cognitive ability variable as the dependent variable as measured by assessing The Peabody Individual Achievement Test (mathematics, reading recognition, and reading comprehension). The results of his

study indicate that birth order has a negative and significant effect on cognitive abilities. It is because individuals born earlier are gifted with better genes and benefit from more quality time.

Castex and Kogan Dechter (2014) examined changes in returns to formal education and cognitive abilities over the past 20 years. The method used is 2SLS, so there is no bias due to measurement errors. The data used in this study included measures of cognitive abilities, education, and other family and personal characteristics. The natural logarithm of wages is the dependent variable. In contrast, the explanatory variable is the educational dummy measured by cognitive abilities using the Armed Forces Qualification Test (AFQT) score in math and verbal scores.

The results of the study found that cognitive abilities were positively related to wages. Cognitive skills have an effect of 30 percent to 50 percent on wages.
The results of the research by Castex and Kogan Dechter (2014) are also supported by research by Lee and Newhouse (2012); Lindqvist and Vestman (2011). Lee and Newhouse (2012) conducted a study on the relationship of cognitive abilities and labor market outcomes in countries participating in the PISA and TIMSS tests. The study results found that higher test scores improved job quality and labor market outcomes in the form of wages. In addition, a higher test score reduces unemployment and has a positive effect on income. Lindqvist and Vestman (2011) investigated the effect of cognitive abilities on labor market outcomes using data from Swedish military enlistment. The natural logarithm of wages as the dependent variable and cognitive abilities as the independent variable. The study results found that the increase in individual cognitive abilities predicts an increase in the wage logarithm of 8.6 points.

The theory and previous research presented show that the background variables of family socioeconomic status such as income, education, and parental health affect children's cognitive abilities. Child characteristics such as birth order also have a significant effect on cognitive abilities. Children's cognitive abilities here also affect educational outcomes in educational attainment and labor market outcomes in the form of wages. The approach used in this study is quantitative. Creswell & Creswell (2018, p. 41) define quantitative research as an approach that tests objective theory by examining the relationship between variables. These variables will be measured using specific instruments so that data in the form of numbers can be analyzed using statistical procedures.

This study used OLS and Instrumental Variable-Two Stage Least Squares (IV-2SLS) methods. The OLS method is used to estimate the factors that affect children's cognitive abilities, such as family socioeconomic factors, children's characteristics, and others. The IV-2SLS method is used to estimate the effect of cognitive abilities on educational outcomes and the labor market. The use of the IV-2SLS is to overcome the possibility of errors in measuring cognitive scores.

This study uses secondary data from the Indonesia Family Life Survey (IFLS) in 2000 and 2014. IFLS is provided by the RAND corporation, longitudinal survey data at the household, individual, community, and facility levels in 13 provinces in Indonesia. The sample represents about 83 percent of Indonesia's population and contains more than 30,000 individuals living in 13 of the 27 Provinces. The IFLS survey consisted of five waves, including IFLS1 conducted in 1993; IFLS2 was implemented in 1997 and 1998; IFLS3 was conducted in 2000; IFLS4 was implemented in 2007; and IFLS5 was implemented 2014 (Rand, 2018).

The empirical model in this study is used to examine the determinants of children's cognitive abilities and their effects on educational attainment and labor market outcomes. The analysis employs Ordinary Least Squares (OLS) and

Instrumental Variable (IV) estimation. OLS is used to estimate the relationship between cognitive ability and its determinants, while the IV approach is applied to address potential endogeneity in estimating the effect of cognitive ability on later outcomes.

The first model examines the determinants of cognitive ability among children aged 7–14 years. Cognitive score is used as the dependent variable, while the explanatory variables include family socioeconomic background, child characteristics, household size, and residential location. The family socioeconomic background vector consists of parental age, parental gender, the natural logarithm of parental income, parental education, parental psychological health, and the natural logarithm of educational expenditure. The child characteristics vector includes the child's age, gender, and birth order. Residential location is represented by a dummy variable equal to 1 for urban areas and 0 for rural areas.

The second model examines the effect of childhood cognitive ability on educational attainment and labor market outcomes. Educational attainment is measured by years of schooling, while labor market performance is measured by the natural logarithm of wages earned over 12 months. Cognitive score is the main explanatory variable in both specifications.

In the empirical equations, the constant represents the intercept, while the coefficients measure the estimated effects of the independent variables. The subscript i refers to the individual sample, t represents the year of observation, namely 2000 and 2014, and the error term captures unobserved factors affecting the dependent variable. Overall, the empirical framework allows the study to identify the main factors associated with cognitive development and assess whether cognitive abilities developed during childhood are related to subsequent educational and labor market outcomes.

Results and Discussion

This study uses the OLS regression method which is used to determine the relationship between the socioeconomic background of the family such as parents' income, parents' education, expenditure on education, psychological health of parents, number of household members, and location of residence, as well as the characteristics of children in the order of birth to cognitive scores in Indonesia.

Table 4.3 shows the results of the regression that explain the effect of the variables of family socioeconomic background and child characteristics on cognitive scores in 2000. The R2 value of the regression results is 0.243. It means that the independent variables together can explain the dependent variable by 24.30 percent. The estimation results show that parents' education and the natural logarithm of expenditure on education are significantly positively correlated with cognitive scores at the one percent level. The psychological health variable of parents is significantly positively correlated with cognitive scores at the 10 percent level. The variables of child's age and location of residence were also significantly positively correlated with cognitive scores at the one percent level. On the other hand, the birth order variable was significantly negatively correlated with cognitive scores at the 10 percent level.

The estimation results in Table 1 show that parents' level of education as measured by the length of school can increase children's cognitive scores. If the parents' length of schooling is increased by one year, it can increase 0.78 children's cognitive scores. Likewise, the natural logarithm of the expenditure on education, if the spending on education increases by one percent, can increase 3.8 percent of the child's cognitive score. The psychological health of good parents also makes the

child's cognitive score higher by 4 (four) than the psychological health of poor parents. The higher the age of the child also affects the cognitive score. If the child's age increases by one year, the cognitive score will increase by 3.83. Children who live in cities have a relatively higher cognitive score of 6.28 than children who live in villages. On the other hand, the child's birth order can lower cognitive scores. If the child's birth order is increased by one unit, it can reduce 15.46 cognitive scores.

Table 1. Cognitive Ability Determinant Model Estimation Year 2000

Independent Variable	Cognitive Score
Constant	-1.421
	(24.23)
Parent's income log	-0.898
	(1.266)
Education expense log	3.816***
	(1.373)
Head of household education	0.780***
	(0.281)
Psychological health of parents (1=Good)	3.977*
	(2.191)
Parent's age	-0.00349
	(0.186)
Birth order	-15.46*
	(8.257)
Child's gender (1=male)	-1.778
	(2.234)
Child's age	3.832***
	(0.505)
Location (1=City)	6.282***
	(2.339)
Number of household members	-0.854
	(0.812)
Observation	363
R^2	0.243

Robust standard errors in parentheses
*** p<0.01, **p<0.05, *p<0.1
Source: Processed by the author

In this section, we will present the estimation results of the hypothetical model like mother like son, like father like daughter. This hypothesis describes the cross-cognitive ability of the sexes. In general, it was found that smart boys were found to be associated with smart mothers, and conversely, smart girls had highly educated fathers. The estimation results related to the hypothesis are presented in the following table.

Parents pass their intelligence genes on to their children. Fathers tend to pass their intelligence genes on to their daughters, as evidenced by the estimation results above. The father's education variable was significantly positively correlated with daughters' cognitive scores, at the 5 percent level. Father's education measured by the length of school is associated with an increase in the cognitive score of daughters. If the father's length of school is increased by one year, it can increase the cognitive score of 0.630 girls.

Table 2. Estimating the Effect of Parental Education on Children's Cognitive Score Skor

Variable	Girls Cognitive Score	Boys Cognitive Score
Constant	62.140*** (2.724)	45.290*** (5.601)
Father's Education	0.635** (0.321)	
Mother's Education		2.540*** (0.702)
Observation	243	50
R^2	0.016	0.215
Root MSE	22.635	22.429

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Processed by the author

On the other hand, mothers tend to pass their intelligence genes on to their sons, as evidenced by the estimation results, which show that the mother's education variable is significantly positively correlated with the boys' cognitive scores at the 1 percent level. As measured by the length of schooling, mothers' education can also improve their sons' cognitive scores. If the mother's length of education is increased by one year, it can increase the cognitive score of 2.540 boys.

The effect of children's cognitive scores on educational attainment and their impact on labor market outcomes was estimated using IV-2SLS with the variable cognitive score as the instrument. The variable of children's educational attainment as measured by years of schooling and the natural logarithm of wages is endogenous.

The estimation results in Table 3 show that the cognitive score has a significant positive correlation on the educational attainment in question at the one percent level. It means that an increase in children's cognitive scores has the opportunity to increase their educational attainment. An increase in a child's cognitive score by one unit impacts an increase in the length of school by 0.040 years. The educational attainment of children as measured by years of schooling also has a significant positive correlation with the natural logarithm of wages at the 5 percent level, which means that an increase in the length of education for children will increase their wages. If the length of schooling is increased by one year, it will increase wages by 0.150 percent. The results of the IV-2SLS estimation are as follows:

Based on the results of the estimation of the determinants of cognitive abilities in section 4.3, the family's socioeconomic background in the form of parents' education level significantly influences children's cognitive scores. It is by the results of research by Burhan et al. (2017); Wang et al., (2020); and Chen et al. (2018). Parents with higher levels of education have higher educational expectations for their children. In everyday life, parents tend to supervise their children more closely, and parents often involve their children in academic activities. It results in better cognitive development and academic achievement of children.

Tabel 3. Estimation Results of the Effect of Cognitive Score on Educational Achievement

Variable	***first stage*** ***Years of schooling***	***second stage*** **Natural Logarithm of Wages**
Constant	8.220*** (0.538)	14.08*** (0.743)
Cognitive Score	0.0482*** (0.007)	

Years of schooling		0.156**
		(0.063)
Observations	363	363

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Processed by the author

On the other hand, cognitive abilities in children are also explained by intelligence genes from parents, where mothers pass their intelligence to sons and vice versa. The natural logarithm of spending on children's education has a significant effect on cognitive scores. These results also support research by Kang (2007) that spending on education causes an increase in children's test scores. Parents who allocate their income for children's education costs, such as buying school equipment, pocket money, and courses, allow children's intellectual development to be better.

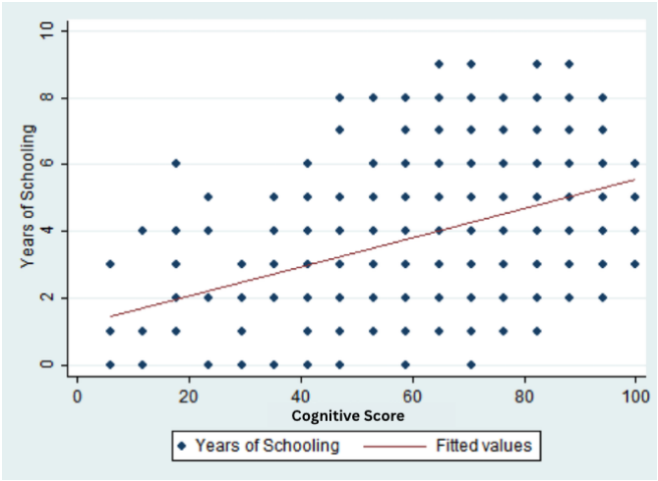
The child's birth order has a negative and significant effect on cognitive scores. It shows that the eldest child has a much better cognitive ability than the child born later in life. These results also support research by Heiland (2009); Black et al., (2011); and Monfardini and See (2016) that birth order can affect children's cognitive abilities. Children with the first birth order receive special attention from their parents than children born later in life. The eldest child also benefits more when parents' financial resources are abundant. The needs of children with first birth order in education can also be met and impact better cognitive abilities.

The psychological health of parents also influences children's cognitive abilities. It is indicated by the estimation results that show that parents' psychological health is positively and significantly correlated with cognitive scores. The better psychological health of parents, the better the child's development, especially on the child's cognitive abilities. Following the results of research by Mensah and Kiernan (2010), children whose parents experience high levels of psychological pressure are estimated to have low cognitive scores. Mensah and Kiernan (2010) stated that the poor psychological health of parents is also a signal of socioeconomic difficulties in the family. So, in this case, the need to improve the socioeconomic status in the family and the need for integration between psychological health and social interventions to improve the welfare of the family itself and the cognitive development of children.

Location of residence affects children's cognitive scores. The coefficient value in the estimation results shows that children's cognitive abilities who live in cities are higher than children who live in villages. These results also support research by Alexopoulos (1997) that children's cognitive scores as measured by IQ are indeed higher in urban areas than in rural areas. It is due to the influence of the school's social environment. The community environment in the countryside is very different from the environment in urban areas. Libraries and other facilities are often inaccessible in rural areas (Alexopoulos, 1997). There is a tendency for individuals who are intellectually superior to live in cities.

Cognitive ability has a significant influence on academic outcomes. The estimation results show that cognitive scores have a positive and significant effect on educational attainment. It is by research by Schoon (2010) that individuals with high cognitive abilities achieve academic achievement at a higher age.

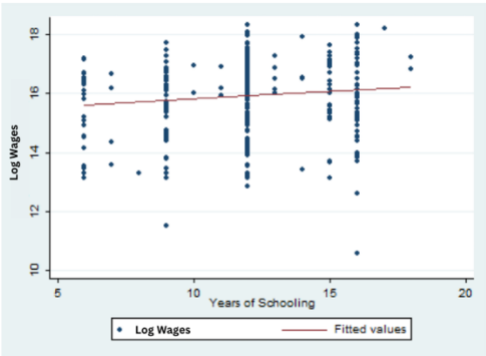
Figure 3. Scatter Plot Cognitive Score against Years of Schooling



Source: Processed by the author

The following presents a scatter plot to support the results of research related to the relationship between cognitive scores and educational attainment. Figure 3 shows that the cognitive scores of children aged 7-14 years in Indonesia have a positive relationship with the length of schooling. Monitoring of children's intellectual development by parents is essential to support their children's educational needs.

Figure 4. Scatter Plot Years of Schooling against Logarirma Natural Wages



Source: Processed by the author

Cognitive ability is also an essential factor in labor market outcomes, namely wages. Better cognitive abilities of children with higher educational attainment will lead to better wages as well. Based on the estimation results, educational attainment as measured by years of schooling positively influences labor market outcomes, namely wages. These results also support research by Mitra (2000); Lee and Newhouse (2012); and Lindqvist and Vestman (2011) that the length of school determines success in the labor market.

The results of this study are also supported based on research data presented in the form of a scatter plot of years of schooling against the natural logarithm of wages. Figure 4 shows that educational attainment as measured by years of education has a positive relationship with Indonesia's natural logarithm of wages.

It means that individuals with good cognitive abilities and educational attainment will lead to good quality individuals entering the labor market and impacting wages.

Conclusion

The socioeconomic status in the family, which includes parental education, expenses for children's education, parents' psychological health, location of residence, and other factors such as birth order, significantly affect children's cognitive abilities as measured by cognitive test scores. Cognitive abilities explain success in educational attainment and labor market outcomes, namely wages, as evidenced by cognitive scores that positively and significantly affect the length of schooling and salaries. Parents with a better level of education pass on intelligence to their children. A good level of maternal education has a positive relationship with better cognitive boys. Vice versa, the level of education of a good father has a positive relationship with better cognitive daughters.

AI declaration

The authors declare that artificial intelligence (AI) tools were used solely to assist in language refinement, grammar checking, and improving the clarity of writing. The use of AI did not influence the research design, data collection, data analysis, interpretation of results, or the development of conclusions. All intellectual contributions, including conceptualization, methodology, analysis, and final content, remain the full responsibility of the authors.

Conflict Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper. The research was conducted independently without any financial, commercial, or personal relationships that could be construed as a potential conflict of interest.

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