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Why are cognitive abilities of children so different across countries? The link between major socioeconomic factors and PISA test scores

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Abstract

Path analysis was employed to examine the effects of socioeconomic factors on children's level of cognitive ability (measured by PISA scores) at a cross-country level (*N*=55). The results showed that children's level of schooling had a positive direct effect on their cognitive ability, while the direct effects of adult fertility rate and child mortality were significantly negative. As we found that child mortality had the largest total effect on cognitive ability, the results also confirmed that per capita income had indirectly channeled its positive effect on cognitive ability through the reduction in child mortality. Moreover, in the long term, parents' education level had the largest positive indirect effect on cognitive ability because it significantly increased children's schooling rate and reduced the fertility rate. We suggest that, in the countries considered herein, well-educated parents have higher awareness of quality of life that indirectly raises the cognitive ability of their children.

Keywords: cognitive ability; cross-country analysis; education; parents; PISA scores; socioeconomic

JEL Classifications: I25, J13, O20

1. Introduction

Nations with high intelligence (IQ) societies contribute most to the global income because they are more efficient and productive than those with low IQs. However, the difference in national average IQ has produced a large productivity gap between countries. In particular, global discrepancies in productivity growth owing to differences in IQ will further worsen the wealth inequality between rich and poor countries (Jones & Schneider, 2006;

Lynn & Vanhanen, 2002, 2006). Therefore, considering that IQ is the most significant human capital variable for economic growth, improving the national IQ of poor countries can be the best approach to reduce global inequality in wealth. It has been suggested that long-term increases in a population's IQ, known as the 'Flynn effect' (Flynn, 2009; Neisser, 1997), are achievable, especially because the IQs of children are partially determined by environmental influences such as socioeconomic factors before they start school (Carlsson, Dahl, Öckert, & Rooth, 2015; Cunha & Heckman, 2007). Cognitive development occurs mostly in childhood, and thus a person's lifetime IQ is strongly associated with socioeconomic factors experienced in childhood (Brinch & Galloway, 2012), when children spend most of their time with family, under parental decisions and responsibility (Sclafani, 2004).

Most of the evidence in the literature suggests that three socioeconomic factors, namely, children's schooling, fertility rate (i.e., density of siblings), and children's health, are interrelated and have direct impacts on children's IQ at a population level (e.g., Aslund & Gronqvist, 2010; Black, Devereux, & Salvanes, 2007; Le Carret, Lafont, Letenneur, Dartigues, Mayo, & Fabrigoule, 2003). On the other hand, some studies argue that parents' income and educational levels are antecedent factors that influence variation in IQ-associated socioeconomic factors (e.g., Bacharach & Baumeister, 1998; Johnson et al., 2007). From this it can be understood that, in the long term, these socioeconomic factors are linked in a way through which a variable can indirectly determine children's IQ through the effects of other variables. However, the majority of previous studies on this subject have focused on individual, developed countries where cohort data are readily available for conducting longitudinal studies; thus, the least-developed countries have not been studied extensively. Even at the global scale, for example, the international data on children's cognitive skills, such as test scores in the Programme for International Student Assessment (PISA) presented by the United Nations, are not available for most of the least-developed countries, especially those in Africa (OECD, 2016). However, in this study, we suggest that the least-developed countries with low IQs (Lynn and Vanhanen, 2002, 2006; Meisenberg & Lynn, 2011) can learn from the global trend of socioeconomic development that has influenced the variation in IQ across the more developed countries over the past few decades. In particular, while the literature lacks a study examining the interactions among the five aforementioned socioeconomic factors and their impact on children's IQ at the global scale, it is more informative to concentrate on specific socioeconomic factors across countries rather than specific countries across many factors to provide useful models and lessons for most of the least-developed countries to emulate. For that reason, we investigated how these socioeconomic factors interact to influence variation in children's IQ. By determining the strength of the effect of each major socioeconomic factor on children's IQ, especially in the least-developed countries, the long-term increase in IQ can be modelled with an aim to reduce the productivity gap at the global scale.

2. Theoretical Framework

Initially, the definition of intelligence (IQ) assumed that an individual's IQ or cognitive ability is innate and genetically determined; thus, it was assumed that IQ is fixed and stable over time. Nevertheless, it has become clear that an individual's IQ is not static, but is adaptable and sensitive to environmental influences (Perkins, 1996). IQ is not entirely hereditary, but rather results from interactions between genes and environments that help shape cognitive skills, encompassing both genetic and acquired characters (Cunha & Heckman, 2007). In this study, we consider two components of intelligence, namely, phenotypic intelligence, which is measured intelligence due to environmental factors, and genotypic intelligence, the genetic component of intelligence (Lynn & Harvey, 2008;

Retherford & Sewell, 1998). Accordingly, even with genotypic intelligence, if the environmental factors that stimulate phenotypic intelligence are not present, cognitive skills and talents will not develop. Hence, in the presence of specific environmental influences, an individual's cognitive test scores may vary significantly over a life span.

In the present study, we examined the impact of socioeconomic factors on children's cognitive ability at a cross-country level. Cognitive ability in our study is represented by the test scores from the PISA organized by the Organisation for Economic Co-operation and Development (OECD). The PISA measures the cognitive skills of 15-year-old children in mathematics, science, and reading. The international scholastic achievement test scores have been frequently employed as a proxy for the national average level of cognitive ability and skills. Educational studies, such as Rindermann (2007) and Rindermann and Ceci (2009), have treated PISA scores as an international measure of cognitive competence at a cross-country level. Moreover, prominent economic-growth studies such as Hanushek and Kimko (2000) and Hanushek and Woessmann (2012) have employed the international scholastic achievement test scores as a proxy for cognitive achievement and have used them to compare nations. These two studies averaged the test scores for two study subjects, mathematics and science, to construct a single value to measure the cognitive skills of each country, assuming that math and science abilities are the main elements of cognitive ability. On the other hand, well-known studies such as Lynn and Mikk (2009), Lynn, Meisenberg, Mikk, and Williams (2007), Lynn and Vanhanen (2012), Rindermann and Thompson (2011), and Rindermann, Sailer, and Thompson (2009) averaged the values for reading achievement along with math and science tests scores to construct cross-country data on cognitive ability, acknowledging that reading literacy is an important element of human intelligence, as suggested by Carroll

(1993, pp. 598–599).[1] However, Rindermann (2007) reported that combining the math, science, and reading subtest scores of PISA does not lead to significant differences in results compared to using mathematics achievement alone, because the three subtests are heavily loaded with tests of general cognitive ability. Because of this, a high correlation (r > .90) reported between IQ and scholastic achievement scores has been interpreted to mean that these two variables may be measures of the same construct (Lynn, Meisenberg, Mikk, & Williams, 2007; Rindermann, 2007). However, in the current study, we suggest that employing PISA test scores is more relevant than national average IQ (e.g., Lynn & Vanhanen, 2002, 2006, 2012) because the test scores are obtained during a specific year for each country. This is essential to understand the effects of socioeconomic variables on children's cognitive ability during specific periods.

Previous studies have established that cognitive ability is significantly associated -at both individual and country levels- with socioeconomic indicators such as corruption, somatic health, income and productivity data, and self-employment rates among immigrants (Kuncel, Rose, Ejiogu, & Yang, 2014; Lynn & Vanhanen, 2012; Potrafke, 2012; Ram, 2007; Sörberg, Allebeck, & Hemmingsson, 2014; Vinogradov & Kolvereid, 2010). For instance, For instance, Lynn and Vanhanen (2012, pp. 70–72, 76–77) reviewed the literature on cognitive ability and a consistent positive effect in worker's productivity. These authors have found that this effect is larger at the population level than at the individual level. Cognitive ability is correlated with income at .31 and .69 for individual and country levels, respectively. At the state level Kanazawa (2006) verified a correlation of .50 between cognitive ability and income across the fifty U.S. states—a value that is in the range of .31 to .69. The strength of the relationship differs because individuals tend to cooperate through positive assortative

[1] Many previous studies transformed the average math, science, and reading scores into the IQ scale. However, in this study, we keep the PISA scores on their original scale.

matching when they work in groups (state or country). This results into a magnified effect of cognitive ability on income at a country level (Burhan, Sidek, Kurniawan, & Mohamad, 2015; Hanushek & Kimko, 2000; Jones, 2013; Jones, 2011; Jones & Schneider, 2010; Kremer, 1993). The direction of the relationship between cognitive ability and socioeconomic factors is consistent across individuals and populations.

In this paper, first, we explore the economics, psychology, and sociology literature to identify important socioeconomic factors that influence children's level of cognitive ability. Second, we employ a path analysis to empirically examine how these identified socioeconomic variables interact to influence cognitive ability, as described in Figure 1.

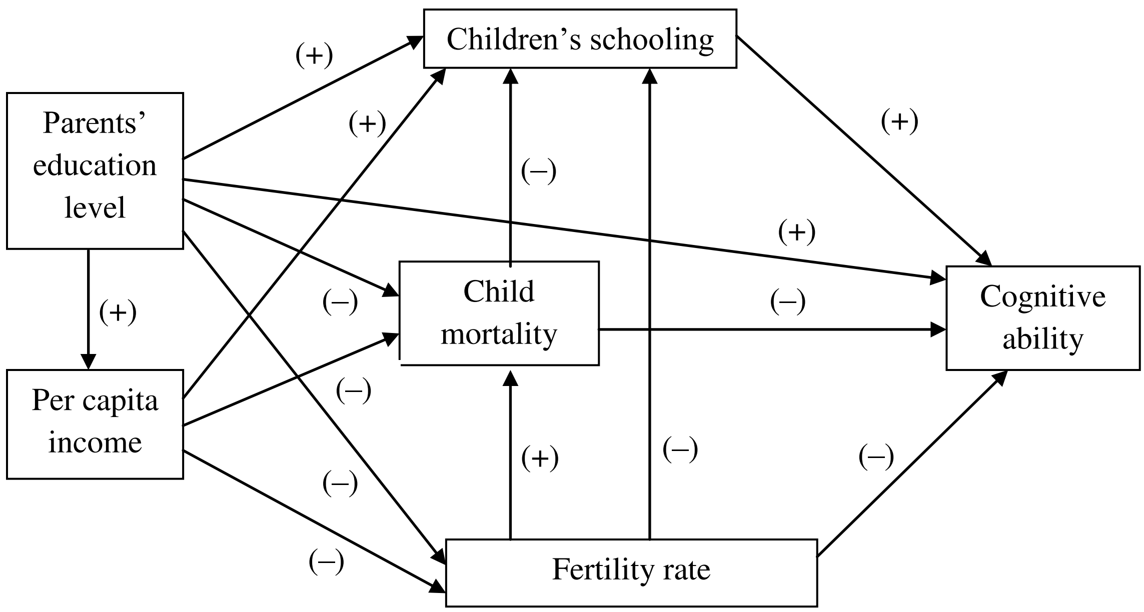


Figure 1. The possible interactions between parents' education level, per capita income, adult's fertility rate, children's health and schooling, and their effects on children's cognitive ability. The positive (+) and negative (–) signs indicate the direction of their relationships.

Based on the literature, we hypothesize that schooling has a direct impact on raising cognitive ability because formal education enriches the cognitive skills and knowledge of children (Brinch & Galloway, 2012; Cascio & Lewis, 2006; Falch & Massih, 2011; Glymour et al., 2008; Hansen, Heckman, & Mullen, 2004; Haworth, Daleb, & Plomin, 2008). It has been observed that the impact of extra school days on cognitive skills is homogeneous across individuals with different school grade history and whose parents have different levels of education (e.g., Carlsson, Dahl, Öckert, & Rooth, 2015). This partially supports previous findings that schooling is more significant than family background in determining academic performance across countries (e.g., Heyneman, 1976; Heyneman & Loxley, 1983; Hungi & Thuku, 2010).

Other than schooling, studies have shown that children's health is an indispensable determinant of human capital across countries, in which health is a component that forms other types of human capital (Bleakley, 2010). In particular, deprived health and nutrition during childhood will discourage schooling and hinder children's capacity to learn (Glewwe & Miguel, 2007; Sigman, Newman, Jansen, & Bwibo, 1989). In recent decades, there have still been a large number of children with poor health in certain populations. In 1990, 12.4 million children below the age of 5 years died worldwide. This was reduced to 6.9 million in 2011 (UNICEF, 2012a), in which about two-fifth of this mortality resulted from acute respiratory illnesses, diarrhea, and undernourishment (Black, Morris & Bryce, 2003); malaria and measles were also important causes (UNICEF, 2012b). Studies have raised concern about the impact of early childhood health on future cognitive ability. For example, efficient cognitive functioning requires sufficient intake of nutrition because nutrients help the development of brain cells (Grantham-McGregor, Walker, Chang, & Powell, 1997). Children who are malnourished or have low birth weights are more likely to score lower on IQ or academic tests, and consequently, may experience grade repetition and lower educational attainment (Behrman & Rosenzweig, 2004; Black, Devereux, & Salvanes, 2005a, 2007; Currie & Stabile, 2003; Ding, Lehrer, Rosenquist, & Audrain-McGovern, 2009; Glewwe, Jacoby & King, 2001). This implies that government interventions such as medication endowment policies are essential to help raise the level of schooling and academic performance (Leslie & Jamison, 1990; Miguel & Kremer, 2004).

A universal finding in the literature related to family background and children's outcome is that adult fertility rate has negative impacts on children's intellectual, educational, and health outcomes (e.g., Aslund & Gronqvist, 2010; Black, Devereux & Salvanes, 2005a; Hatton & Martin, 2010; Rosenzweig & Zhang, 2009; Silles, 2010). These impacts are associated with the quantity–quality trade-off theory of fertility, which states that an increasing number of children within a family will compel the parents to decrease human capital investments per child (e.g., Angrist, Lavy, & Schlosser, 2010; Becker & Lewis, 1973; Becker & Tomes, 1976; Kalemli-Ozcan, 2003; Rosenzweig & Zhang, 2009). On a larger scale, the theory states that due to technological progress within a society, returns to education have increased, and therefore, parents are more likely to invest heavily in the quality of their children. Regarding the relationship between fertility rate and children's outcome, psychology literature often employs two main theories, namely, confluence theory and the resource-dilution hypothesis. Confluence theory asserts that a child's cognitive ability is fashioned by the average intellectual skills in his or her family. In particular, parents possess much greater intellectual skills than children. Therefore, the arrival of newborn children with lower initial cognitive skills will reduce the family's average intellectual ability. As a result, families with a larger number of children will exhibit an intellectually 'immature' environment because of the larger ratio of individuals with lower absolute intelligence (Zajonc, 1976, 1983, 2001; Zajonc & Markus, 1975). In contrast, the resource-dilution hypothesis claims that the growing dilution of parental resources in a large family is the grounds for why children with fewer siblings are more educated and healthier than those with larger sibship size (e.g. Anastasi, 1956; Blake, 1981, 1985, 1989; Downey, 2001;

Steelman, Powell, Werum & Carter, 2002). As the sibship size expands, the amount of parental income and other resources allocated to each child in the family shrinks. Rivalrous resources, for instance, money to be spent for better healthcare and education, will become diluted proportionately as the number of children in a family escalates (Downey, 1995; Jaeger, 2009; Steelman et al., 2002). Therefore, a high fertility rate will directly and indirectly bring about poor outcomes regarding children's level of health, schooling, and cognitive ability.

Moreover, the literature suggests that parents' educational attainment has a significant relationship with their children's level of cognitive ability. This is owing to the fact that a higher educational level in parents indicates a superior level of intelligence, which is then transmitted to children. For example, Black et al. (2005b) and Clouston, Kuh, Herd et al. (2012) suggested that parents' educational attainment is reflected by their own IQ, which is then passed on through their children. Therefore, one can find significantly positive correlations between parents' and children's educational attainment and income across populations (Dearden, Machin, & Reed, 1997; Hertz, 2007; Solon, 1999). In addition, parents' education level may have indirect effects on children's IQ through its direct effects on fertility rate, children's health, and children's schooling. In particular, well-educated parents are more aware of the importance of formal schooling in enriching the intellectual capital of their children. Thus, they are more engaged in their children's schooling, while at the same time, they provide a mentally stimulating environment that favors the intergenerational transmission of human capital (Ann, 1993; Davis-Kean, 2005; De Fraja, Oliveira, & Zanchi, 2010; Mahamood et al., 2002; Neuman & Dickinson, 2002; Sclafani, 2004; Umek, Podlesek, & Fekonja, 2005). Therefore, parents' educational level has a positive relationship with children's school enrollment (Dearden, Machin, & Reed, 1997; Hertz et al., 2007; Oreopoulos, Page, & Stevens, 2006; Solon, 1999). Furthermore, more education improves parents' ability to acquire health knowledge, which helps them to learn about the prevention of diseases and to understand medical treatment instructions (National Science Foundation, 2000; Case, Fertig, & Paxson, 2005; Lakdawalla & Goldman, 2001; Goldman & Smith, 2002; William et al., 1998). Therefore, well-educated parents have healthier children because they can provide their children with healthier lifestyles, such as better nourishment and a hygienic environment (Arya & Devi, 1991; Behrman & Deolalikar, 1988; Cutler & Lleras-Muney, 2008; Desai & Alva, 1998; Glewwe, 1999; Kunwar & Pillai, 2002; Lindeboom, Llena-Nozal & Van Der Klaauw, 2009; Lleras-Muney, 2005; Meara, 2001; Sive, Subotzky & Malan, 1993; Strauss & Thomas, 1998). Finally, regarding the relationships between parents' education level and their children's education and health, more-educated parents tend to have higher incomes with which to afford the costs of schooling and health care for their children (Autor, Katz, Kearney, 2008; Case, Lubotsky, & Paxson, 2002; Ermisch, 2003; Ermisch & Pronzato, 2010). Due to strong preferences for pursuing professional careers, highly educated parents tend to experience a delay in having children and to incur a greater opportunity cost of leaving high-income jobs for child rearing (Barro & Becker, 1988; Black, Devereux, & Salvanes, 2008; Fort, 2009; Handa, 2000; Livi-Baci, 1997; Monstad, Propper, & Salvanes, 2008; Montgomery & Trussell, 1986; Subbarao & Raney, 1995). Therefore, highly educated parents often desire fewer children of the best quality, consistent with the quantity-–quality trade-off theory of fertility (Becker & Lewis, 1973; Bongarts, 2003, 2010).

3. Methods

3.1 Variables and Data

To examine the socioeconomic determinants of cognitive ability, we employed PISA test scores as a proxy for the cognitive ability of nations. The PISA is the largest ongoing international study of cognitive performance, and it is conducted on 15-year-old children. PISA scores are advantageous because the data are obtained during a specific year for each country, which is fundamental to understand the timing of the effects of socioeconomic variables on children's cognitive ability. In the present study, the data were retrieved from the OECD database (OECD, 2010, 2013). For each country, the scores were then averaged for the years 2009 and 2012 for mathematics, reading, and science achievements. This produced a more stable value of cognitive skills for each country covered in this study. The PISA scores were employed instead of the Trends in International Mathematics and Science Study (TIMSS) test scores because the former measures how much children can apply the science and mathematics skills they have learned in schools, rather than how much they had learned in their classrooms as applied in the TIMSS (Hutchison & Schagen, 2007). Hence, PISA scores are the most comparable to standard IQ tests because they emphasize items that require connections between existing knowledge rather than simple recollection of facts.

The literature suggests that adult fertility rate has a significant influence on children's level of cognitive ability, health, and schooling outcomes. In particular, larger sibship size directly and indirectly slow down the cognitive development of children, as explained by confluence theory and the resource-dilution hypothesis. To measure this, we employed the total fertility rate of the population to represent children's sibship size. Considering that the PISA test was conducted on 15-year-old children during the years 2009 and 2012, we concluded that they were born in 1994 to 1997. Hence, we employed the total fertility rate (births per woman) averaged for the period 1994 to 1997. The data were obtained from the World Development Indicators (WDI) database (World Bank, 2013).

Moreover, children's health is an important factor influencing school enrollment and cognitive ability. To represent children's health status, we employed the under-five mortality rate, which is the probability per 1,000 that a newborn baby will die before reaching the age of 5 years. Early childhood health is very crucial for the development of brain cells and cognitive skills in children. Furthermore, deterioration of health in children will prevent them from attending school. Because the PISA's 2009 and 2012 candidates were born in 1994 to 1997, respectively, the data on under-five mortality rate were averaged for 8 years, from 1994 to 2001. The data were obtained from the WDI database (World Bank, 2013).

One of the foremost determinants of children's cognitive ability is the knowledge and skills they learn at school. In this paper, we employ the secondary school enrollment rate as a proxy for children's schooling. The data were obtained from the WDI database (World Bank, 2013), and were averaged for 10 years, from 2000 to 2009. There are several reasons why employing secondary school enrollment is better than primary or tertiary education enrollment rates when determining PISA scores. First, secondary education enrollment indicates the completion of primary education. Students are assumed to have learned basic literacy, numeracy, and cognitive skills in primary school. Second, students internationally take the PISA test when they are 15 years old, which is commonly accepted as the age of secondary school where more complex skills are taught. Therefore, there is no effect of tertiary education on the PISA scores.

Other than children's schooling, parents' education level may have both direct and indirect effects on children's cognitive ability. To represent the parents' level of education, we employed the average number of years of education of adults (age≥25) obtained from the

Barro and Lee (2010) dataset. For each country, the values were averaged for the years 1970–1995. This variable is useful because it may reflect the direct intergenerational transmission of intelligence for parents and their children in the long term, since higher educational attainment among parents may indicate their higher cognitive ability (Black et al., 2005b; Clouston et al., 2012).

Finally, the literature suggests that household level of income may have indirect effects on children's cognitive ability through its effects on fertility, health, and schooling. A higher income may directly reduce the fertility rate because a rise in income may discourage parents from leaving the labor market for child rearing. Furthermore, the household level of income is influenced by parents' level of education. We suggest employing the gross domestic product (GDP) per capita as a proxy for household income. Considering that the oldest children in our study sample were born in 1994, and the youngest group took the PISA in 2012, we employed the GDP per capita (constant 2005 USD) averaged for 1994–2011. The data were obtained from the Penn World Table 7.1 (Heston, Summers, & Aten, 2012), which were then log-transformed because an increase in expenditure or wealth at lower levels would have been more important than at higher levels (Rindermann & Thompson, 2011). Table 1 lists the countries included in this study, ranked by cognitive ability.

Table 1
List of countries ranked by cognitive ability.

Country	Cognitive Ability [a]	Parents' Education [b]	Per Capita Income [c]	Fertility Rate [d]	Child Mortality [e]	Children's Schooling [f]
South Korea	541.83	8.168	20410.7	1.610	5.713	95.09
Finland	536.50	8.267	29334.5	1.793	4.725	95.19
Japan	534.83	9.370	30318.2	1.434	5.100	99.29
Estonia	519.83	8.990	12914.3	1.316	13.463	88.73
Netherland	518.67	9.674	34827.8	1.540	6.550	88.64
Switzerland	517.83	9.665	36169.3	1.485	5.975	84.02
New Zealand	516.67	11.748	24989.9	1.975	8.038	93.04
Australia	515.50	11.499	35664.3	1.810	6.613	85.48
Poland	510.83	8.159	12215.0	1.625	11.775	91.88
Belgium	509.50	8.630	32043.8	1.568	6.675	88.07
Ireland	506.17	9.944	33592.2	1.890	7.238	93.34
United Kingdom	501.17	7.696	30831.3	1.723	6.875	94.45
Slovenia	498.67	7.571	20659.0	1.285	6.413	91.37
Denmark	498.50	9.392	32757.7	1.778	6.025	90.17
France	498.33	6.665	29624.6	1.748	5.888	95.48
Norway	498.17	9.939	46029.4	1.873	5.275	95.74
United States	494.17	12.045	39239.2	1.982	8.925	89.30
Iceland	492.83	7.893	38190.8	2.095	4.613	86.91
Hungary	491.00	8.993	14380.7	1.513	12.525	89.23
Latvia	490.33	7.080	9768.2	1.228	20.400	85.76
Portugal	488.83	5.419	19102.8	1.428	8.588	80.55
Sweden	488.67	9.538	31061.7	1.683	4.425	97.58
Italy	487.83	6.644	28350.7	1.208	6.500	91.17
Spain	486.67	5.716	25994.1	1.170	7.325	92.82
Luxembourg	485.67	8.583	65916.2	1.718	5.588	82.10
Lithuania	481.33	7.555	10954.4	1.520	13.950	93.15
Croatia	478.17	7.364	12443.6	1.603	9.138	86.44
Greece	469.33	7.236	22662.8	1.323	8.975	86.69
Israel	466.33	10.195	22871.4	2.910	7.763	99.20
Turkey	458.17	3.695	8629.6	2.689	45.825	72.86
Malta	455.33	7.465	19390.8	1.943	8.438	78.75
Serbia	444.50	7.346	6545.7	1.650	15.738	89.91
Cyprus	442.33	7.716	17326.7	2.078	7.800	92.84
Chile	437.67	7.234	10072.4	2.354	12.063	83.89
Bulgaria	436.17	8.438	7932.9	1.233	22.313	85.56
UAE	435.67	3.888	60902.6	3.311	12.188	78.00
Romania	433.50	8.394	7206.6	1.343	29.688	80.02
Thailand	429.50	4.155	6532.1	1.847	25.838	70.09
Uruguay	419.33	6.655	8953.3	2.380	18.725	67.92
Mexico	418.67	4.852	11070.5	2.933	30.038	65.61

Country	Cognitive Ability [a]	Parents' Education [b]	Per Capita Income [c]	Fertility Rate [d]	Child Mortality [e]	Children's Schooling [f]
Mauritius	414.67	5.070	7924.7	2.138	20.775	69.21
Venezuela	413.67	4.793	8874.1	3.055	23.675	62.15
Trinidad & T.	413.33	7.175	19344.9	1.935	29.100	67.46
Malaysia	413.17	5.552	9869.8	3.297	11.850	68.94
Kazakhstan	407.50	6.954	7303.4	2.168	49.075	87.69
Jordan	400.17	4.263	3777.0	4.609	29.713	80.45
Moldova	399.33	7.131	1957.5	1.847	33.500	80.31
Argentina	396.17	7.351	9548.3	2.744	21.788	82.19
Colombia	395.67	4.888	6401.5	2.848	27.538	67.33
Albania	389.67	7.666	4333.5	2.694	32.175	68.52
Indonesia	384.83	3.334	3120.7	2.665	59.388	56.36
Qatar	377.83	4.895	72344.4	3.562	13.825	77.09
Peru	371.50	5.992	5382.8	3.275	48.588	71.53
Panama	369.00	6.609	7693.5	2.894	27.175	63.49
Kyrgyzstan	325.00	7.304	1760.7	3.058	57.625	80.94

Note:

[a] Cognitive ability: PISA test score, averaged for 2009 and 2012 for mathematics, science, and reading.

[b] Parents' education: Mean years of schooling of adult (aged≥25), averaged for 1970–1995.

[c] Per capita income: GDP per capita (constant 2005 USD), averaged for 1994–2011.

[d] Fertility rate: Total fertility rate (births per woman), averaged for 1994–1997.

[e] Child mortality: Under-five mortality rate (per 1000 births), averaged for 1994–2001.

[f] Children's schooling: Secondary education enrolment ratio, averaged for 2000–2009.

3.2 Analysis

We conducted a path analysis using maximum likelihood estimation (MLE) to examine the interactions among socioeconomic variables and their effects on children's cognitive ability, as illustrated in Figure 1. Amos 21.0 (SPSS, Inc) was used to conduct CFA on the relationships among parents' education level, household income, fertility rate, children's schooling, child mortality, and cognitive ability. Following Shrout and Bolger (2002), we performed random sampling with replacement to generate 10,000 bootstrap samples from the original dataset (N = 55) to determine the significance of the mediating effects. With these bootstrap samples, the model was tested 10,000 times, which resulted in

10,000 estimates of path coefficients of the indirect effects. Indirect effects were considered to be statistically significant at the .05 level if the 95% confidence interval for these estimates did not contain 0 (Frazier et al., 2004; Preacher & Hayes, 2004; Shrout & Bolger, 2002).

4. Results

Table 2 presents a correlation matrix of the variables employed in the path analysis. Cognitive ability was significantly correlated with other variables at the 1% significance level. It was positively correlated with parents' education level, per capita income, and children's schooling, but negatively correlated with fertility rate and child mortality.

Table 2
Correlation matrix for all variables.

	Variable	1	2	3	4	5	6
1	Cognitive ability	1.000					
2	Parents' education	.599**	1.000				
3	Per capita income	.683**	.436**	1.000			
4	Fertility rate	–.694**	–.490**	–.321*	1.000		
5	Child mortality	–.774**	–.518**	–.796**	.477**	1.000	
6	Children's schooling	.734**	.662**	.512**	–.544**	–.641**	1.000

Note: $*p < .05$; $**p < .01$.

Figure 2 shows the results of path analysis.[2] We found that fertility rate, child mortality, and children's schooling had statistically significant effects on cognitive ability. Fertility rate had a nonsignificant effect on children's schooling. Parents' education had a statistically significant effect on income, fertility rate, and children's schooling, but a

[2] See Table A1 in Appendix A for details on the results.

nonsignificant effect on cognitive ability and child mortality.[3] Regarding the significant correlation between income and fertility, we found that this association was no longer significant in the presence of parents' education in the path model. However, per capita income rather than parents' education statistically significantly reduced the child mortality rate. Not shown in Figure 2, our bootstrap analysis indicated that the direct effect of child mortality (β=-.342; p=.120) on children's schooling became significant at the p<.01 level when the direct effects of per capita income (β=.011; p=.972) and fertility rate (β=-.187; p=.139) on schooling were removed from the path model.[4,5] Therefore, we chose to maintain the direct effect of mortality on schooling in the model.

[3] One might suggest that parent's education and per capita are just correlated, because their correlation r=.436 is of the same value with the effect of parents' education level (β=.436) on income in the regression. However, it has been widely suggested in the literature that their relationship is causal, running from parents' education to their income. Furthermore, data on parents' education (year 1970–1995) and per capita income (year 1994–2011) were measured at two different times, which allowed parents' education to have an effect on their income in our path model. A simple regression of per capita income on parents' education alone without controlling for other factors is not a novel idea. A number of economics studies, for instance, Jones and Schneider (2010) and Zax and Rees (2002), have conducted a simple regression of earnings on IQ alone to determine the true effect of cognitive skills on per capita income.

[4] Since the direct effect of per capita income on schooling had the largest p-value (.972), we removed it from the path model. By doing so, we found that the direct effect of fertility rate on schooling was non-significant even at the 10% level, while the direct effect of child mortality on schooling was significant at the 1% level.

[5] See Tables A1 and A2 in Appendix A for details on the results.

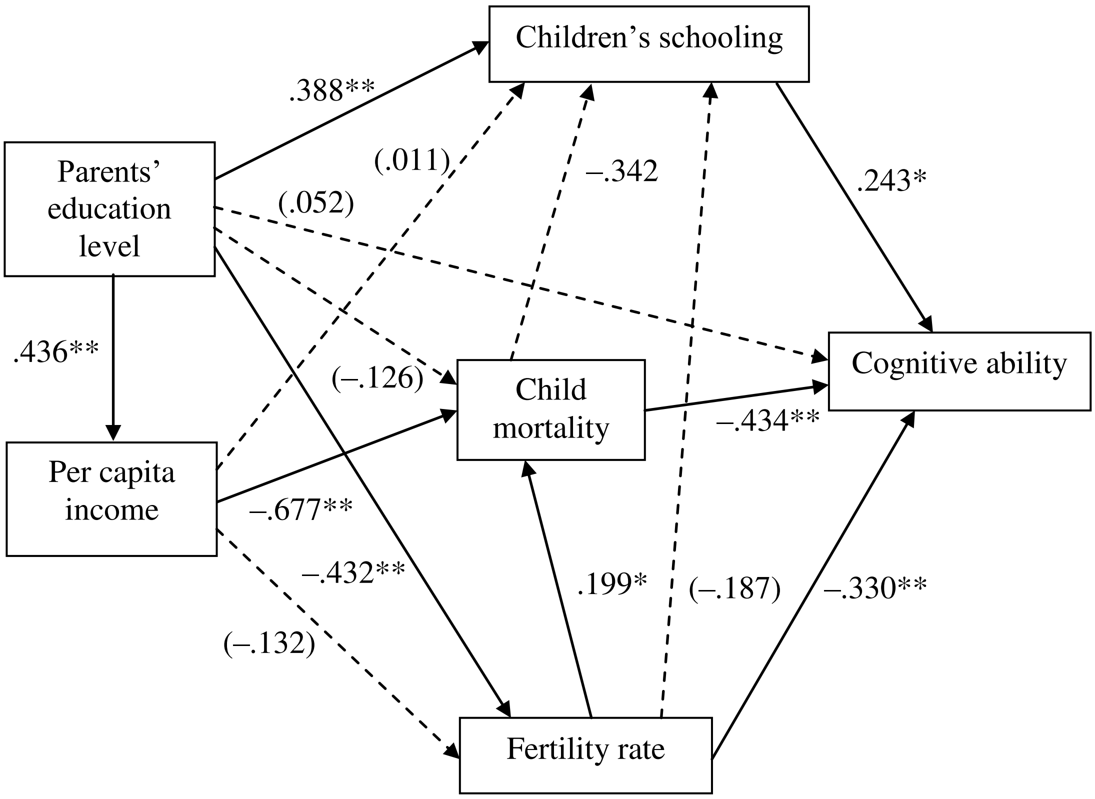
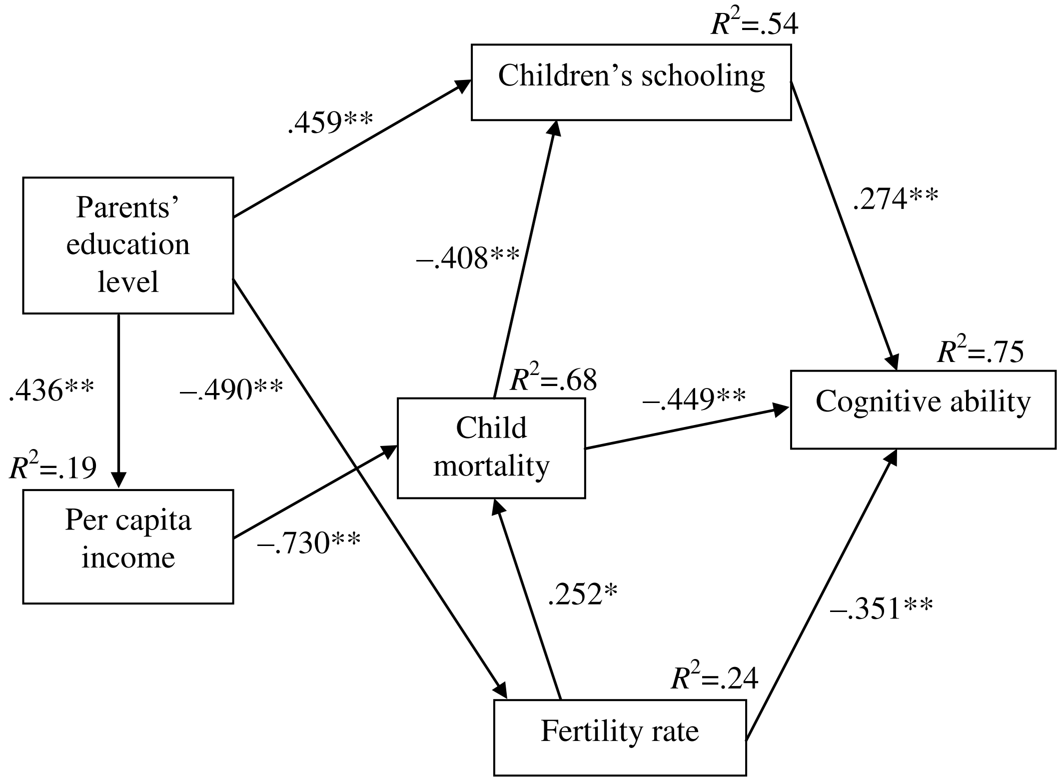


Figure 2. Standardized path coefficients between parents' education level, household per capita income, children's schooling, fertility rate, child mortality, and children's cognitive ability. Solid lines represent significant pathways at *p<.05 and **p<.01, and nonsignificant paths are represented by dotted lines, which could be removed from the models. Regressions were estimated with 10,000 bootstrap replications. See Tables A1 and A2 in Appendix A for details on the results.

Figure 3 shows the refined model after removing nonsignificant paths.[6] Fertility rate, child mortality, and children's schooling explained about 75% of the variation in cognitive ability. Parents' education had a highly significant effect on increasing the children's schooling rate (β=.459; p<.01) and reducing the fertility rate (β=–.490; p<.01). The effects of per capita income (β=–.730) and fertility rate (β=.252) on child mortality were statistically significant at the p<0.01 and p<0.05 levels, respectively, with an R^2 of .68. We found that the value of the discrepancy chi square (Chisq) was greater than .05, while the chi square/degree of freedom ratio (Chisq/df) was less than 5.0. Furthermore, the values of the goodness of fit

[6] See Table A2 in Appendix A for details on the results.

index (GFI), comparative fit index (CFI), Tucker-Lewis index (TLI), and normed fit index (NFI) were greater than .90 or .95. These results indicate acceptable or good model fits (Hair, Black, Babin, Anderson, & Tatham, 2010; Holmes-Smith, Coote, & Cunningham, 2006).



Goodness of fit indexes:

1. P–Value = .090
2. GFI = .939
3. CFI = .976
4. TLI = .941
5. NFI = .951
6. ChiSq/df = 1.824

Figure 3. Standardized paths coefficients at the *p<.05 and **p<.01 for the interactions between parents' education level, household per capita income, children's schooling, fertility rate, child mortality, and children's cognitive ability. Regressions were estimated with 10,000 bootstrap replications. See Tables A1 and A2 in Appendix A for details on the results.

Tables 3 and 4, respectively, show the indirect and total effects of variables in the model.[7] Most of the indirect and total effects were statistically significant at the p<.01 level. Parents' education (β=.546) had the largest indirect effect on children's cognitive ability, followed by per capita income (β=.409), fertility rate (β=–.142), and child mortality (β=–.112). However, considering the total effect of each variable, we found that child mortality (β=–.560) and parents' education (β=.546) had the largest total effects on the cognitive ability of children. These were followed by the fertility rate (β=–.493), per capita income (β=.409), and children's schooling (β=.274). Therefore, the total effect of parents' education and child mortality on cognitive ability were two times larger than that of children's schooling.

Table 3
Standardized indirect effects of variables.

Variable	Parents' education	Per capita income	Fertility rate	Child mortality	Children's schooling
Per capita income	–	–	–	–	–
Fertility rate	–	–	–	–	–
Child mortality	–.442**	–	–	–	–
Children's schooling	.180**	.298**	–.103*	–	–
Cognitive ability	.546**	.409**	–.142*	–.112**	–

Note: *p<.05, **p<.01. See Table A3 in Appendix A for details on the results.

[7] See Tables A3 and A4 in Appendix A for details on the results.

Table 4
Standardized total effects of variables.

Variable	Parents' education	Per capita income	Fertility rate	Child mortality	Children's schooling
Per capita income	.436**	–	–	–	–
Fertility rate	–.490**	–	–	–	–
Child mortality	–.442**	–.730**	.252*	–	–
Children's schooling	.639**	.298**	–.103*	–.408**	–
Cognitive ability	.546**	.409**	–.493**	–.560**	.274**

Note: **p*<.05, ***p*<.01. See Table A4 in Appendix A for details on the results.

5. Discussion

In summary, the results showed that there are three socioeconomic factors that have statistically significant direct effects on children's cognitive ability: child mortality (β=–.45), total fertility rate (β=–.35), and children's school enrollment (β=.27). At a cross-country level, cognitive ability can be greatly improved by reducing child mortality. This is in line with the literature, which suggests that improving children's health in their early years has a very significant effect on boosting their cognitive abilities in the teenage years. Additionally, in the model, child mortality had the largest total effect (β=–.56) on cognitive ability. This finding is consistent with the literature, which indicates that high cognitive functioning requires excellent health in childhood especially for cognitive development (e.g., Currie & Stabile, 2003; Ding et al., 2009). Moreover, we verified that reducing the fertility rate has a statistically significant effect on increasing children's level of cognitive ability. This finding is in accordance with confluence theory, which claims that a decline in the expected number of children born in a given year will improve the total intellectual level of a family, thereby raising the aggregate IQ level per child (Zajonc, 2001; Zajonc & Markus, 1975). Finally, a rise in school enrollment among children has a statistically significant effect on increasing their level of cognitive ability, although its direct effect is lower than that of child mortality and fertility rate. Schooling improves knowledge and cognitive skills in children through cognitively demanding activities that improve their working memory and executive functioning (Deary et al., 2004; Haworth et al., 2008; Whalley & Deary, 2001).

Reducing the fertility rate and raising the per capita income were found to have positive direct effects on children's health. This may occur through two mechanisms. First, a reduction in fertility rate may directly reduce child mortality (β=.25) by increasing the amount of health resources allocated to each child in a family, which is consistent with the resource-dilution hypothesis. These health resources include medications and treatments, as well as a healthy and sufficient food supply, which are essential for cognitive development (Downey, 2001; Steelman et al., 2002). This explains why fertility rate has a large total effect (β=–.49) on cognitive ability. Second, a rise in income may reduce the rate of child mortality, with a very strong effect size (β=–.73). Consistent with the literature, we suggest that chronic diseases that require a higher proportion of household income to be spent on medical costs predominantly cause child mortality. Education may help parents to acquire knowledge on children's health, but their income is indispensable to reduce child mortality through the treatment of chronic diseases (Autor et al., 2008; Case et al., 2002; Lahema, Martikainen, Laaksonen, & Aittomaki, 2004). On the other hand, parents' education level has statistically significant indirect effects on reducing child mortality because it significantly increases their level of income (β=.44) and reduces the fertility rate (β=.49). This explains why parents' education has the largest indirect effect (β=.55) on the cognitive ability of children.

Moreover, the significant effect of parents' education level (β=.46) on children's schooling supports previous evidence that well-educated parents have positive attitudes towards children's schooling (e.g., De Fraja et al., 2010; Umek et al., 2005). However, child mortality rate has an adverse effect (β=–.41) on their schooling, thus showing that sick children are deprived of attending school (Bleakley, 2010; Case et al., 2005). Controlling for the effects of parents' education level and child mortality, we did not find any significant direct effects of per capita income and fertility rate on children's schooling. These findings provide empirical support for the literature that suggests that household income has negligible effects on school enrollment decisions (e.g., Carneiro & Heckman, 2002; Chevalier & Lanot, 2002), and that most of the total effect of parents' education level on children's schooling is direct and independent of income or the number of children in the household (Chevalier, 2004).

Finally, an increase in per capita income has a nonsignificant effect on reducing the fertility rate. It can be suggested that a rise in income may increase the opportunity cost of leaving the labor market for child rearing, as the two variables in our study were significantly correlated (r=–.32) at the 5% level. However, this effect was attenuated by a strong effect of parents' education level (β=–.49) on fertility rate. This finding, along with our findings on the significant effect of parents' education (β=.46) rather than income and fertility rate on children's level of schooling, suggest that parents' education level has the largest indirect effect (β=.55) on children's cognitive ability because well-educated parents provide their children with high-quality early-life environments that contribute to the development of cognitive skills.

The results of our path analysis showed that a reduction in child mortality has the largest total effect (β=-.56) on cognitive ability. Based on this finding, we recommend that government subsidies for children's healthcare should be a main concern, because health is an important factor that facilitates other types of human capital (Bleakley, 2010). Furthermore, the exceptionally stronger effect of per capita income (β=-.73) than fertility rate (β=.25) on child mortality suggests that the government needs to put more effort into raising the income of the poor, so that all parents can afford healthcare for their children. In relation to this, it is important to ensure that domestic and foreign direct investments benefit not only the high-skilled industries but also create employment opportunities for the poor, especially those with low skills. Moreover, the credit market should be made more lenient to stimulate self-employment among the poor (Blanchflower & Oswald, 1998; Karlan & Zinman, 2008). Altogether, increasing government healthcare subsidies, income, and the employment rate among the poor must be of high priority to improve children's health, especially because parents' educational level can only have an indirect effect in this process.

Reducing the fertility rate is very effective for improving children's health and cognitive ability. Modern societies should be educated about birth-control methods and the negative effects that high fertility rates have on children's cognitive abilities. Although governmental intervention may contribute to population control, it is important to realize that parents' educational level has a large direct effect (β=-.49) on the fertility rate. We suggest that parents' level of educational plays an essential role in shaping the future quality and well-being of children. In previous studies related to quality of life, for instance, highly educated parents were more likely to stick with birth-control methods (e.g., De Walque, 2007; Rosenzweig & Schultz, 1985, 1989; Sedgh, Hussain, Bankole, & Singh, 2007) and provide their children with healthier lifestyles (e.g., Desai & Alva, 1998; Glewwe, 1999, Lindeboom, Llena-Nozal & Van Der Klaauw, 2009). Additionally, well-educated parents also tend to send their children to school rather than to work (e.g., Hussain & Maskus, 2003; Mukherjee & Das, 2008; Sakellariou & Lall, 2000). In the same line of thought, we perceive that the educational level of parents may reflect their degree of awareness of children's quality of life, and those who are highly educated are more likely to focus on broad, long-term goals for their children. We suggest that the educational institution is a key element that contributes to societal quality of life, which then facilitates the transmission of desirable attitudes, values, knowledge, and skills to the next generation. In the short term, children's schooling has a modest direct impact (β=.27) on their cognitive ability, but in the long-term, when the children become parents, their educational background will result in a large total effect (β=.55) on the ability of the next generation, indirectly through the effects of fertility, household income, and children's schooling, as we have found in this study. Our study corroborates evidence that intergenerational transmission of human capital is more likely to occur through a stimulating environment provided by well-educated parents (Björklund, Lindahl, & Plug, 2006; Johnson et al., 2007; Sacerdote, 2002; Umek, Podlesek, & Fekonja, 2005). Therefore, as the basis of societal progress across generations, we suggest that formal education should not merely focus on attracting children to stay longer in school through an old-fashioned examination-oriented education system. Instead, educational institutions should be able to enhance children's understanding of the world they live in, and empower them to become active participants in the future transformation of their societies (United Nations, 2014).

Finally, an interesting finding from our study is the fact that parents' education level does not have a direct impact on children's cognitive ability. This implies that an increase in the educational attainment of parents will not directly translate into higher cognitive skills of the population. Specifically, we suggest that if parents' educational attainment indicates their level of cognitive skills, we should have observed a statistically significant effect of parents' educational level on children's cognitive ability, owing to genetic transmission of intelligence from parents to children (Black, Devereux, & Salvanes, 2009; Bouchard, Lykken, McGue, Segal, & Tellegen, 1990; Krapohl & Plomin, 2016; Plomin & Deary, 2015). Therefore, it is worth suggesting that education and health policies to improve the societal level of cognitive ability must be focused on children and implemented during the early stages of childhood. Education in adulthood or late teenage years with extra effort may have a positive effect on cognitive skills, but is more difficult than that of early childhood (Brinch & Galloway, 2012; Cunha & Heckman, 2007).

Appendix A, Table A1
Standardized and unstandardized direct effects for all variables in the path model.

Parameter			Regression Weights: Unstandardized Estimates	Regression Weights: Standardized Estimates	Original Sample (N=55): Standard Error	Original Sample (N=55): Critical Ratio	Original Sample (N=55): p-value	Bootstrapped Sample (10,000 replications): Lower Bounds of 95% CI	Bootstrapped Sample (10,000 replications): Upper Bounds of 95% CI	Bootstrapped Sample (10,000 replications): p-value of CI
Per capita income	<---	Parents' education	.080	.436	.023	3.563	***	.032	.119	.002
Fertility rate	<---	Parents' education	-.156	-.432	.047	-3.310	***	-.273	-.028	.018
Fertility rate	<---	Per capita income	-.259	-.132	.256	-1.013	.311	-.983	.346	.445
Child mortality	<---	Fertility rate	3.838	.199	1.672	2.295	.022	.444	8.166	.024
Child mortality	<---	Per capita income	-25.647	-.677	3.175	-8.077	***	-32.820	-19.023	.000
Child mortality	<---	Parents' education	-.877	-.126	.635	-1.382	.167	-2.213	.236	.114
Children's schooling	<---	Child mortality	-.260	-.342	.121	-2.141	.032	-.674	.062	.120
Children's schooling	<---	Parents' education	2.048	.388	.575	3.560	***	.915	3.382	.000
Children's schooling	<---	Per capita income	.308	.011	4.204	.073	.942	-9.390	10.526	.972
Children's schooling	<---	Fertility rate	-2.739	-.187	1.561	-1.755	.079	-7.659	.638	.139
Cognitive ability	<---	Children's schooling	1.169	.243	.483	2.420	.016	.144	2.163	.024
Cognitive ability	<---	Fertility rate	-23.257	-.330	5.649	-4.117	***	-37.548	-12.608	.000
Cognitive ability	<---	Child mortality	-1.584	-.434	.317	-4.997	***	-2.349	-.469	.007
Cognitive ability	<---	Parents' education	1.314	.052	2.264	.580	.562	-4.934	4.841	.730

Please note that not all the parameters are shown in Figure 2. Since the direct effect of per capita income on children's schooling -highlighted in shading- had the largest p-value (.972), we removed it from the path model. By doing so, we found that the direct effect of fertility rate on schooling was non-significant even at the 10% level, while the direct effect of child mortality on schooling become significant at the 1% level. Moreover, our bootstrap analysis indicate that the direct effect of child mortality on schooling (β=-.342; p=.120) was significant at the p<.01 level when the direct effects of fertility rate (β=-.187; p=.139) and per capita income (β=.011; p=.972) on schooling were removed from the path model. Therefore, we chose to maintain the direct effect of child mortality on children's schooling in the model. See Table A2 of Appendix A.

Appendix A, Table A2
Standardized and unstandardized direct effects for all variables in the path model after the removal of non-significant paths.

Parameter			Regression Weights		Original Sample (*N*=55)			Bootstrapped Sample (10,000 replications)		
			Unstandardized Estimates	Standardized Estimates	Standard Error	Critical Ratio	*p*-value	Lower Bounds of 95% CI	Upper Bounds of 95% CI	*p*-value of CI
Fertility rate	<---	Parents' education	-.177	-.490	.043	-4.130	***	-.647	-.261	.000
Per capita income	<---	Parents' education	.080	.436	.023	3.563	***	.162	.655	.002
Child mortality	<---	Fertility rate	4.787	.252	1.504	3.182	.001	.060	.406	.011
Child mortality	<---	Per capita income	-27.130	-.730	2.948	-9.203	***	-.816	-.627	.001
Children's schooling	<---	Child mortality	-.309	-.408	.078	-3.973	***	-.627	-.199	.000
Children's schooling	<---	Parents' education	2.378	.459	.532	4.470	***	.256	.640	.000
Cognitive ability	<---	Children's schooling	1.292	.274	.411	3.146	.002	.098	.483	.003
Cognitive ability	<---	Fertility rate	-23.847	-.351	5.121	-4.657	***	-.500	-.202	.000
Cognitive ability	<---	Child mortality	-1.607	-.449	.314	-5.121	***	-.627	-.147	.005

Appendix A, Table A3
Standardized indirect effects for all variables in the path model.

Standardized Indirect Effects for All Variables in the Path Model (Bootstrapped Sample: 10,000 replications)					
	Parents' education	Per capita income	Fertility rate	Child mortality	Children's schooling
Per capita income	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...
Fertility rate	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...
Child mortality	β=-.442 [-.581, -.269] p=.001	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...
Children's schooling	β=.180 [.081, .327] p=.000	β=.298 [.141, .458] p=.000	β=-.103 [-.221, -.021] p=.008	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...
Cognitive ability	β=.546 [.405, .653] p=.000	β=.409 [.244, .559] p=.000	β=-.142 [-.237, -.043] p=.007	β=-.112 [-.296, -.037] p=.001	β=.000 [.000, .000] ...

Please note that for each bracket, the Confidence Interval is at the 95% level of significance.

Appendix A, Table A4
Standardized total effects for all variables in the path model.

Standardized Total Effects for All Variables in the Path Model
(Bootstrapped Sample: 10,000 replications)

	Parents' education	Per capita income	Fertility rate	Child mortality	Children's schooling
Per capita income	β=.436 [.162, .655] p=.002	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...
Fertility rate	β=-.490 [-.647, -.261] p=.000	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...
Child mortality	β=-.442 [-.581, -.269] p=.001	β=-.730 [-.816, -.627] p=.001	β=.252 [.060, .406] p=.011	β=.000 [.000, .000] ...	β=.000 [.000, .000] ...
Children's schooling	β=.639 [.492, .759] p=.000	β=.298 [.141, .458] p=.000	β=-.103 [-.221, -.021] p=.008	β=-.408 [-.627, -.199] p=.000	β=.000 [.000, .000] ...
Cognitive ability	β=.546 [.405, .653] p=.000	β=.409 [.244, .559] p=.000	β=-.493 [-.658, -.323] p=.000	β=-.560 [-.705, -.369] p=.000	β=.274 [.098, .483] p=.003

Please note that for each bracket, the Confidence Interval is at the 95% level of significance.

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