Early Life Determinants of Cognitive Ability:
A Comparative Study on Madagascar and Senegal

Heidi Kaila,[1] David E. Sahn,[2] Naveen Sunder[3]

October 2016

WORK IN PROGRESS

ABSTRACT

We study the determinants of educational and human capital outcomes of young adults in Madagascar and Senegal by estimating a production function for cognitive ability. We use unique and comparable panel data sets from both countries and find strong evidence that cognitive skills measured by test scores in the second year of schooling, as well as health, using height as a proxy, are strong predictors of school attainment and cognitive ability in young adulthood in both countries. We also find that early life conditions, particularly the wealth and education levels of parents, have an enduring impact on the test scores of young adults, over and above the mediating impact of early test scores and health. We find that math scores are more important predictors of cognitive skills and education level than are French scores.

Keywords: Education, cognitive ability, human capital, test scores

JEL Classification Codes: I21, O12

Acknowledgments: We thank Andinet Woldemichael for his excellent inputs on the Madagascar data and the financial support of the World Bank, African Development Bank, UK Department for International Development (DFID), and the Institute for the Study of Labor (IZA), for the benefit of developing countries. The views expressed are not necessarily those of any of these institutions.

[1] University of Copenhagen. Email: heidi.kaila@econ.ku.dk
[2] Cornell University, IZA
[3] Cornell University

1. Introduction

In this paper we study the determinants of cognitive ability and human capital of young adults. By using a cognitive ability production function, we examine the importance of early life inputs such as health and parental inputs, as well as cognitive ability in early life, to understand how the educational level and cognitive capacity of young adults are formed. To do so, we rely on two unique and very similar panel surveys from Madagascar and Senegal that follow children from the time they enter second grade in school until they are young adults. The cohort is thus followed over a period of 17 years in Senegal and 15 years in Madagascar, an unusually long period of time for surveys, and especially important, since the surveys include information on cognition that spans from early childhood to young adulthood.

The research on the effects of early life conditions and ability on success in later life is generally quite limited. The most rigorous studies on the issue have been conducted in developed country settings where studies both in economics and psychology have shown that children with high academic performance in elementary school are also much more likely to have higher academic performance later in life, as measured in terms of school attainment and human capital, as measured in terms of test scores (Cunningham and Stanovich 1997; Feinstein 2003; Bourne et al. 2006; Duncan et al. 2007).[4]

In developing countries, the evidence on the impact of early ability on human capital accumulation is very limited due to the lack of long-term panel data and, in particular, the lack of data on academic performance that spans the period from early childhood to young adulthood. Among the limited evidence, we are aware of two studies from India where Helmers and Patnam (2011) found evidence of self-productivity of cognitive skills from the ages 5 to 12, and Singh and Mukherjee (2015) found that early primary school skills contribute to the likelihood of completing secondary education.[5] In the context of Guatemala, Behrman et al. (2008) found that schooling has a significant impact on adult reading comprehension. In none of these cases, however, was the impact of early ability on school attainment and human capital of young adult examined. In the African context, there is an even a great paucity of evidence, with respect to the impact of early cognitive ability on later life outcomes. Exceptions, albeit which cover a much more limited time span, are Glick and Sahn (2010) and Aubery and Sahn (2014). By using the first two rounds of our Senegal data set, Glick and Sahn (2010) found that skills in early primary school in

---

4 For a review article on effects of early life attributes to adult outcomes and their relation to social mobility, see Heckman and Mosso (2014).

5 The two latter references related to the Young Lives project, which has followed a cohort of children for 11 years as of the time of the writing of this paper. Details: http://www.younglives-india.org/findings-and-data .

1995–6 are strongly positively associated with later school progression, surveyed in 2003. Similarly, Aubery and Sahn (2014) found persistence in academic skills in Madagascar using the panel dimension 2003–12. We know of no study from Africa that directly estimates the impact of cognition measured in early life, and family circumstances of young children, on subsequent human capital attainment.

In terms of health, there is a limited literature to suggest that health status early in life, using height measurements as proxy, has an important impact on outcomes in later life. More specifically, there is some strong evidence that health plays a significant role in determining cognitive ability, not only as a child (Duc 2011; Spears 2012), but also as an adult (Behrman et al. 2008; Case and Paxson 2008; Vogl 2014; LaFave and Thomas 2016). Behrman et al. (2008) found that the effect of schooling on adult cognitive skills is overestimated if the health status as a child is not taken into account. This is supported by evidence of the positive relationship with childhood health status and cognitive ability in later life (Alderman et al. 2006). As implied by the cognitive production function (Todd and Wolpin 2003, 2007; Cunha and Heckman 2007; Cunha et al. 2010), and also documented in Case and Paxson (2008), we know that the effect of health in early life affects human capital in later life via the formation of cognitive skills early in life.

Although our focus is thus on the role of early cognitive ability and health, in terms of their impact on human capital formation, we are also interested in the role of family background, particularly wealth and parental education in this regard. Here the literature is more clear in showing that parents' education has also been found to affect grade progression and cognitive skills of their children, both in developing and developed countries (Cunha and Heckman 2007; Todd and Wolpin 2007; Behrman et al. 2008; Cunha et al. 2010; Glick et al. 2011; Jones et al. 2014). In the context of sub-Saharan Africa, Glick et al (2011) and Jones et al. (2014) found that parental background plays a significant role in ability—children of educated and non-poor parents perform much better than their peers. In terms of wealth, or other money metric measures of income, indeed there is considerable evidence that they matter for education and cognition (Cunha and Heckman 2007, 2008; Todd and Wolpin 2007; Behrman et al. 2008; Helmers and Patnam 2011). In the majority of studies from developing countries, however, income, expenditures, or wealth are measured contemporaneously with the cognitive indicator. In contrast, we are interested in early childhood conditions, where we measure wealth basically at the time of entry into school and to evaluate the impact of wealth during young childhood on later life outcomes, controlling for children's health status and cognitive ability at the time that they were in second grade.

We build upon a standard cognitive production function framework (Todd and Wolpin 2003, 2007; Cunha and Heckman, 2007; Cunha et al. 2010). In this framework the cognitive skills are developed over time as a function of inputs from the child's environment, such as parents' education, wealth, and the schooling environment. Parental and school inputs can also be a function of earlier test scores, if parents are willing to invest more in children that have performed better in school (Glick and Sahn 2010).

In this study we examine the production of human capital of young adults in the vastly different contexts of two poor sub-Saharan African countries, Madagascar and Senegal, where the nature and role of schooling, the importance and value of skills, and the social context and related social norms differ, despite many other similarities. Both are low-income countries that struggle with low primary school completion and overall low education levels among their populations, despite marked improvements over the past 20 years. Despite the significant increase in primary school completion rates over 1996–2012—from 40 to 59 percent in Senegal, and from 31 to 70 percent in Madagascar—the completion rates are still far from being universal. Primary school gross enrollment rate in Senegal has increased from 59 percent to 81 percent between 1996 and 2012, and in Madagascar from 86 per cent in 1996 to 145 percent in 2012 (World Bank 2016).[6] In particular, at the time that our cohort of children followed in this study were at the age that they would be starting school, it is clear that in both of the countries there was still a large proportion of children that did not even attend, let alone complete, primary school. For those who attended school in Madagascar and Senegal in the 1990s, grade repetition and dropout rates have both been very high (Michaelowa 2001; Glick and Sahn 2010). In both Senegal and Madagascar, much of the instruction is in French, the primary language of education for both countries, and the countries follow similar educational systems, modeled after that in France. Nonetheless, there are some important differences in the educational system of the countries. Perhaps most important is that Senegal has a system of Koranic schools that offer religious education and where there is a high proportion of preschool students, including even those who subsequently enroll in the secular government schools.

The Malagasy and Senegalese economies differ in many important respects. Madagascar is an island economy that has experienced two periods of political turmoil since 1998, with average GDP per capita growth being zero during the period of our study (Word Bank 2016). In contrast, Senegal is one of the more dynamic economies in West Africa, with GDP per capita growth averaging 1.2 percent between 1995–2012. Likewise, the poverty headcount ratio has increased slightly in Madagascar, to 75 percent in 2010. In Senegal, however, the headcount ratio has decreased to 47 percent in 2010 (Word Bank 2016). Therefore, even though children in Madagascar and Senegal are exposed to similar

[6] Net enrollment rate is not available for Madagascar after 2003. The large disparity in the gross enrollment rates indicates that in Madagascar, there is potentially much more enrollment of overaged or underaged children, as well as grade repetition.

schooling systems, the opportunities they might encounter later in life, and the extent to which their background matters for their achievements in later life, may be very different.

We find that cognitive attainment of young adults is strongly related to cognitive ability at the time of school entry, particularly in Senegal, and that this relationship is stronger for math skills than French language ability, although, the lack of statistically significant effects in the case of Madagascar may in part be due to the smaller sample of children in our models. We also find that height plays an important role in grade attainment in both countries, but only in Madagascar does it matters for cognitive ability formation. As indicators of early life inputs in the production of human capital, we also find that wealth of the household when children are entering school to be an impact on schooling and human capital outcomes of young adults, and that parents' education matters significantly for grade attainment. These findings are in line with those in the literature and generally support a production function approach to cognitive skill formation, where inputs from parents and the environment play a significant role, one that this persists over the life course of the children, independent of the early cognitive ability also included in the model. Interestingly, however, parents' education level is only related to cognitive skill formation in Madagascar, but not in Senegal. In Madagascar mothers' education seems to matter more.

The paper is organized as follows. Section 2 presents the data and some descriptive statistics. In Section 3 we discuss the theoretical and empirical framework, and present the results in Section 4. Finally, Section 5 concludes.

2. Data

For our analysis we use long-term panel data sets from Madagascar and Senegal. The first round of the survey was conducted in 1995–6 in Senegal and 1997–8 in Madagascar, and in both cases involved administering math and French tests to children at the beginning and end of the second grade. The children at that time were in the age range of 7 to 10 years.[7] These school-based tests were administered as part of a multi-country study named, Program on the Analysis of the Conference of Francophone Ministers of Education, which is referred to by its French acronym, PASEC.[8] Urban and rural communities with at least 20 students in a given grade level were included in our sample. From among these

[7] Some children were older or younger because of early or delayed enrollment.

[8] In French, the study name is Programme d'analyse des systèmes éducatifs de la Confemen. They were conducted under the authority of the Conference of Education Ministers for Francophone Africa, CONFEMEN. For more information on the PASEC, see CONFEMEN (1999) and Michaelowa (2001).

communities, some were chosen randomly and were part of the sample where the school-based testing took place. One important implication of this random sampling procedure was that rural PASEC clusters were larger than the average-sized rural communities, especially in Madagascar, since the cluster needed an elementary school with a sufficient number of children in a given grade for the survey. Another important element of the original PASEC sample is that since it was school-based, those children who did not attend school were excluded. Thus, the sample is not representative of the entire cohort of children in the age range in the PASEC clusters, including only those who had enrolled in school.

A subset of the children attending second grade in 1995–6 in Senegal and 1997–8 in Madagascar were re-surveyed in the early 2000s when they were adolescents,[9] and again in 2011–12. The children in this long-term cohort were randomly selected from slightly less than half the original clusters included in the mid-1990s PASEC surveys.[10] The 2011–12 data sets, referred to as the Life Course Transition of Young Adults Surveys in the two respective countries, consist of young adults who were 21 to 23 years old at the time of the survey.

Our final sample includes 333 and 448 children that were in second grade in Madagascar and Senegal, respectively.[11] Most of the attrition in the cohort occurred between the original PASEC surveys and the surveys in the early 2000s. Only around 60 per cent of this population was eventually resurveyed in 2004. Between 2004 and 2012, the attrition rate, in contrast, was much lower, so that overall the attrition rate is around 50 per cent.

In the Senegal sample, of the 20 PASEC children per cluster/school who were tested in second grade in 1995–6, survey enumerators were able to find, on average, 15 children in rural clusters and 17 in urban ones in 2003 (Glick and Sahn 2010). Between 2003 and 2012, the attrition rate was an additional 15 per cent.

Given the more than 15-year span of time separating our first and last surveys, we remain concerned about attrition and the bias it introduces. To better understand this effect, we compared the current sample of children in the cohort with those in the original PASEC samples, which were designed to be representative of school-aged children. Appendix Tables C1a and C1b show a comparison of means for key parameters and outcomes between the original PASEC sample and the cohort in our sample. We find that there are no statistically significant differences for most variables. The math post-test score is lower

[9] These surveys are referred to as the Progression Through School and Academic Performance in Madagascar Study (EPSPAM) and Senegal Household Education and Welfare Survey (EBMS) in Senegal.

[10] The limited number of clusters, or so-called PASEC communities, revisited was due to budgetary constraints in carrying out the survey, especially since the cost of finding the original children was quite high.

[11] The main reason for the smaller sample size in Madagascar is that we only attempted to find 15 randomly selected children from the original PASEC sample per community, compared to 20 in Senegal.

for the students that we were not able to track. Additionally, the French post-test score and the gender of the school director are different in Madagascar between the children in the original sample and those who were in the panel. The number of years of experience of the teacher is the only other variable with a significant difference between panel and non-panel members in Senegal.

Despite there being relatively little difference in the characteristics of the samples, we want to emphasize that we are not making any claims that our cohort is representative of the entire population in this age group since, as noted above, this is a school-based sample and excludes children who had not completed at least one year of schooling at the time of the first survey. Furthermore, the sample is biased in that the smallest and most remote rural villages are not represented, since their schools were too small to qualify for inclusion in the original sample. That being said, we would argue that we have a unique long-term panel from two African countries, spanning from second grade until young adulthood, which includes information on cognition and other socioeconomic characteristics of the children, their families, schools, and communities. There is much to be learned from this panel, despite the recognized limitations in terms of size and attrition.[12]

As indicated above, cognitive skills assessments, in the form of math and French tests, were administered in all survey rounds. Additional information on school characteristics were collected in the original PASEC surveys conducted in the mid–90s, as well as a limited set of household characteristics, including parents' education and assets, that allow us to create a wealth index. More detailed household and community surveys were conducted in the latter rounds of the surveys as well.

Tables 5a and 5b present summary statistics of the variables of interest for Senegal and Madagascar, respectively. In terms of education-related variables, in Senegal the sample on average has completed 9 grades of school, compared to 10 grades in Madagascar. The test score variables are standardized based on the full sample, which explains the mean being close to zero, both in the 1990s and in 2012. We can see that in Senegal, the sample has a slight majority of males, whereas in Madagascar, females have a slight majority. In Madagascar only one-third of the sample resides in an urban area, compared to 60 per cent in Senegal. The Senegalese sample is on average 24 years of age in 2012, compared to 22 years in Madagascar. This is consistent with the second grade baseline data having been collected 2 years earlier in Senegal.

In terms of family characteristics, the Senegalese parents are slightly better educated than the Malagasy parents, and in both countries the fathers have on average 1 more year of

[12] We should note that other unique panels of this type of duration and detail from developing countres, such as the Guatamalan studies (Grajeda et al. 2005; Behrman et al. 2006) and Young Lives studies (see http://www.younglives.org.uk/content/sampling-and-attrition), suffer from similar attrition problems. For a discussion see Alderman et al. (2001).

education than mothers. We also include a z-score of the number of assets the households had at baseline.

The last variables presented are the instruments used, which are discussed more with respect to the estimation strategy and the results.

3. Theoretical and Empirical Framework

In this paper we analyze how early life endowments, particularly cognitive ability, but also health and family background, affect later life outcomes, including grade attainment, and human capital, measured as test scores. Our theoretical framework builds on the work of Todd and Wolpin (2003, 2007) and involves estimating a two-period utility model wherein Period 1 ability is realized, and parents make their investment decisions in children's education according to the knowledge they receive of their children's abilities and health, measured by test scores and nutritional status assessments. The decisions of parents in terms of investing in children's schooling in Period 1 is, in turn, based on the expectation of receiving transfers for their children in Period 2. The utility function therefore consists of current and future consumption of parents. The budget constraint takes into account the costs of schooling, and the amount of investment made by parents depends on many factors: prominent among these factors, especially in resource-constrained environments like Madagascar and Senegal where child labor (including in household production) is widespread, is child cognitive ability and health. In this simple framework, if parents are deciding among multiple children, then parents invest up until the point that the marginal product of that investment is equal across children. Therefore, it is expected to be the case that higher ability and healthier children might get a larger investment than their lower-performing siblings (and peers). If parents' incentives are as the model describes, then they would invest more in a child that has high test scores or better nutrition, relative to a child with lower test scores and poor health status. This would amplify the direct effect of the mere persistence of test scores over time, resulting in high-performing children having even higher performance in the future than the low-performing children.

A simple illustration of the 2-period mechanism in the case of grade attainment is the following:

$$Y_2 = f(\,\beta_1 A_1 + \beta_2 P_1 + \beta_3 H_1 + \beta_4 S_1\,) \ , \qquad (1a)$$

where the grade attainment Y_2 in Period 2 is a function of ability A_1 in Period 1. P_1 denotes parental investments, including the household wealth level in Period 1, as well as the education of the parents; H_1 and S_1 denote the health endowment of a child and school inputs in Period 1, respectively.

In terms of human capital accumulation, the model is,

$$A_2 = g(\gamma_1 A_1 + \gamma_2 P_1 + \gamma_3 H_1 + \gamma_4 S_1) \ , \qquad (1b)$$

where we explain the stock of human capital in Period 2, A_2, using its own lagged value A_1 as an explanatory variable. Otherwise the function is similar to equation (1a).

By using Equation (1c), we can describe iteratively the entire human accumulation process. The stock of human capital is formed in Period 1 by the following process:

$$A_1 = h(\mu_o + \beta_1 A_0 + \beta_2 P_0 + \beta_3 H_0 + \beta_4 S_0) \ , \qquad (1c)$$

where notations are as previously defined. The time index 0 denotes all investments made prior to the first period, that is, from conception to second grade. In addition, we have a genetic component μ_o, which is supposed to capture the pure "ability endowment." Since our cognitive test score data starts at the beginning of the second grade, the school endowments during the first year enrolled are also a component in determining initial period human capital accumulation.

We estimate reduced form regressions from Equation (1a), but not from (1b). Since our data starts at the second grade, we do not have empirical counterparts for Equation (1b), but we do have a very good measure for A_1.

This framework allows us to analyze the relative importance of skills, acquired until the second grade vis-à-vis family background and health, in future schooling human capital accumulation.

In the simplest version, the empirical counterpart of the cognitive production function can be estimated as an OLS model of the following form:

$$Y_i = \beta_o + \beta_1 A_i + \beta_2 Health_i + \beta_4 HH_i + \beta_3 X_i + \varepsilon_i \qquad (2a)$$

In this regression, Y_i stands for the outcome of interest measured in 2012, and A_i stands for a measure of early life ability of the children. $Health_i$ refers to the health inputs received *in utero* and in childhood. HH_i is household level inputs, and X_i denotes control variables. Our dependent variables are performance on French and math tests in 2012, both a composite score and separately, and highest grade completed in 2012.

In our analysis, we measure the early life ability of the student using second grade math and French test scores. The richness of our data provides us with two alternate test scores that we can use here, a pre-test score and a post-test score. The pre-test was administered to students at the start of second grade and the post-test was administered at the end of second grade. In addition to capturing "ability endowment," the second grade scores also include any household and school inputs that the children have received from the point of conception up until the start of second grade.

Test scores typically suffer from measurement errors, as they are based on a one-time spot performances of students, which could be impacted by many factors in the test day environment. If these factors are idiosyncratic, then they would bias the results towards zero. We address these measurement error concerns using an instrumental variable approach. Since we have test score data at the beginning and the end of the second grade, we use the second grade pre-test scores to instrument for the post-test scores. [13]

We could implement this strategy in a couple of different ways—use either the French or math score of one round of tests to instrument for the respective score on the other round, or use the average score of one round to instrument for the average of the other round. For our main specifications, we choose the latter strategy because we want to use a composite measure of ability that is provided by the average of the French and math scores.

It is important to note that the above instrumental variable strategy does not solve the endogeneity bias and simply addresses systematic measurement errors. That is, there could still be unobserved variables that might impact both our outcome of interest and the early life test scores. While other literature that has looked at early childhood ability and how it affects outcomes in adult life, generally it does not concern itself with the possibility of such endogeneity. But to address this possibility, we employ an instrumental variables strategy where we use information on the school characteristics that the child attended in their second grade as an instrument for the early ability, as measured by the test score in second grade.

Our 2SLS model, therefore, takes the following form:

$$TS_i^{post} = \alpha_o + \alpha_1 TS_i^{pre} + \alpha_2 School_i + \alpha_2 Health_i + \alpha_3 X_i + \alpha_4 HH_i + \tau_i \quad (2b)$$

$$Y_i = \gamma_o + \gamma_1 TS_i^{post} + \gamma_2 Health_i + \gamma_4 HH_i + \gamma_3 X_i + \theta_i \ , \quad (2c)$$

where the post- and the pre-test scores in the second grade are denoted by TS_i^{post} and TS_i^{pre}, respectively; $School_i$ denotes characteristics of the school attended in second grade; HH_i refers to household level inputs (parents' education and wealth); and X_i denotes controls. Equation (2b) is the first stage, and Equation (2c) is the second stage equation, which uses the fitted values of the former. In the first stage, the instruments are TS_i^{pre} and $School_i$. In the tables, in one specification we use only one instrument, the pre-test score, so the system is just identified. As mentioned above, this corrects for the measurement error in test scores. In another IV specification, we add school characteristics as additional instruments to correct for endogeneity concerns. The set of instruments vary slightly

[13]Another potential empirical strategy would be to use the pre-test as the input variable of interest and instrument it using the post-test score. This strategy seems to have some issues, because the second stage estimates are highly inflated, most probably due to the violation of the exclusion restriction. Additionally, the exclusion restriction of the instrument is more plausible when the pre-test is used as an instrument for the post-test. So we do not go forward with this technique.

between the two countries, but they include the following variables: years of experience and the gender of the director of the school, as well as the teacher's years of experience.

We show below that these are appropriate instruments since, first, they satisfy the inclusion restriction; that is, the instruments are strongly correlated with the endogenous regressor. As far as the exclusion restriction goes, we argue that the characteristics of the school attended in second grade only has a direct impact on very early cognition (i.e., second grade test scores), and not on eventual grade attainment or gains in cognitive skills over 15 subsequent years of life. That is, the exclusion restrictions imply that the characteristics of the director and the teachers in the school impacts the child's outcomes later in life solely through their impact on early measured ability. The exclusion restriction is not directly testable but is supported by the features of the contexts that we study. Among them is that we know from our school surveys that there is considerable turnover of teachers and directors of schools from year to year. This implies that teachers move between schools frequently, and hence, would only have a temporary effect on the learning outcomes of children. This fact bolsters our exclusion restriction, as compared to a scenario where there is limited teacher mobility, which would lead to teachers affecting students' outcomes for a longer duration of time in primary school. Additionally, the children in the sample all switch to a new school at the end of primary school, i.e., at the end of grade 5. So, while there could be some direct effect of the school characteristics through primary school, this always would be limited, as the children transition out of primary school in their early teens, and we are measuring their cognition in their 20s. We will further show that a range of statistical tests support our use of primary school characteristics as appropriate instruments.

In the main specifications, we look at a composite score of the math and French tests. In latter specifications, we use the French and the math tests scores individually to see if math and French test scores are equally strong predictors for cognition, or if, as found in some literature from the US, math ability is a stronger predictor of human capital in later life (Duncan et al. 2007; Duncan and Magnuson 2011).

4. Results

In the first four columns of Tables 1a and 1b, we show the OLS results for the impact of the cognitive ability in early life on the highest grade attained later in life for survey participants in Senegal and Madagascar, respectively. The highest grade attained might be very different from the number of years of schooling, since repeating grades is quite common in both countries, something found across all school systems in Africa that follow the French model. The first columns of Tables 1a and 1b display the results from simple OLS regressions with a single covariate, the composite post-test score from second grade. In the OLS specifications, a score that is 1 standard deviation above the mean in the second grade implies a rise in highest grade attained by around 1.5 years in Senegal and 1.2 years in Madagascar. When we add a series of household and individual covariates in column 2, we find that the addition of other inputs into this regression leads to a slight fall in these coefficients, although they still remain significant at the 1 percent level.

In columns 3 and 4 of Tables 1a and 1b, we examine how the inclusion of adult height (which is a proxy measure of childhood health and nutritional status) affects this relationship. In column 3 of these tables, we see that when test scores are excluded, height has a positive and significant impact on the highest grade attained in both countries. In our regressions, we use the height z-score[14] as an input in the cognition production function. Hence, it would be useful to know the standard deviation of height, so as to be able to interpret the results meaningfully. The standard deviations of heights are 8.8 cm in Senegal and 7.4 cm in Madagascar. In these specifications, the impact of being 1 standard deviation taller than the mean, leads to an increase in 0.5 years and 0.28 years of schooling in Senegal and Madagascar, respectively. This implies an increase of 0.06 years (Senegal) and 0.04 years (Madagascar) of schooling for every additional centimeter in adult height.

When the test scores are included in column 4, then for both countries we find that height is still significant, although there is a drop in the coefficient as compared to column 3 where the model excludes early life measure of cognitive ability. This suggests that a small part of the impact of child health on adult cognition is operating through early childhood cognitive ability; while in contrast, early child cognitive ability does not operate through health. Comparing columns 3 and 4 in the same tables, we find that the addition of the composite scores lead to the fall in the height coefficient by around 24 percent in Senegal and around 5 percent in Madagascar. To put this in context, Vogl (2014) conducted a similar analysis in Mexico and found that the inclusion of cognition scores in the estimation reduces the height premium in daily earnings by around 13 percent.

Analogously, comparing columns 2 and 4 in Tables 1a and 1b, we find that the coefficient on the second grade composite score falls only 1.4 percent (in Senegal) and 0.7 percent (in Madagascar) when the height z-score is added to the model. Additionally, we did try adding various interactions in these models, including between height and cognition, as well as various interactions between mother's education and assets and early test scores and height. None were significant. This may in part be due to the small sample size in our models.

As explained earlier, the explanatory variable of interest suffers from potential endogeneity and related idiosyncratic measurement error problems, which could lead to a biased estimate of the coefficient. In columns 5 and 6 of Tables 1a and 1b, we report the results from the IV strategy that corrects for these potential biases. The first stage estimates are presented in Tables 4a and 4b for Senegal and Madagascar, respectively.[15] In column 5 of

[14] The z-scores for each country are calculated based on the mean and standard deviation of the heights in that country, as given by our data.

[15] The dependent variable is second-grade post-test scores. Columns 1 and 2 in both tables show that the pre-test score is significantly related with the post-test score, even after controlling for a variety of child cognition

each of Tables 1a and 1b, we include only the pre-test as an instrument. To this specification, we add the other second-grade, school-level characteristics as instruments and report the results in column 6. For the IV regressions in columns 5 and 6 of Tables 1a and 1b, we report the *widtstat*, which is the Cragg-Donald or Kleibergen-Paap F-statistic. When we use only the pre-test score in these regressions, then the F-statistic is 329.5 in Senegal and 129.6 in Madagascar. With the full set of instruments, the F-statistics are 116.9 and 74.5 in Senegal and Madagascar, respectively. These are well above the weak threshold cut-off of 10 (Bound et al. 1995). Additional tests of instrument strength are the F-tests prescribed by Cragg-Donald (1993), Kleibergen-Paap (2006) or the overidentification test by Sargan (J-statistic). Ideally, we would want a high F-stat as per the Cragg-Donald or the Kleibergen-Paap test; which we report as "*widstat*" in our second stage results (described below). We also report the p-values from the Sargan test (J-statistic). The null of the Sargan test is that the instruments are not overidentified, and hence, for the instruments to be valid, we should not be able reject the null hypothesis. This implies that a higher p-value is better. The results for these tests are discussed in detail with the second-stage results.

The second stage IV estimates in columns 5 and 6 of Tables 1a and 1b suggest that scoring 1 standard deviation above the mean in the second grade on a composite math and French score leads to an increase of around 0.8–0.95 (Senegal) and around 0.7 (Madagascar) on the highest grade attained. The effect of height is still positive and significant in each country. Additionally, it is useful to note that the difference between the IV estimates and the OLS estimates is small in Senegal, and even smaller in Madagascar. This difference suggests that there is limited bias to start with in the OLS results, something that we actually would have expected given the long duration of time between the initial measure of cognitive ability and the re-survey, when the cohort members were in their early 20s.

Both the mother's and father's educations have a positive impact on grade attainment in Madagascar. In Senegal, there does not seem to be any impact of mother's education, but somewhat surprisingly, father's education has a negative and significant impact on grade attainment. This points towards a scenario where possibly less educated fathers compensate for their lack of education by investing more in children. Having said that, it is hard to draw any significant conclusions from these results.

Household assets measured in second grade have a large positive and significant impact on highest grade attained across both countries. We enter the assets as z-scores based on an asset index that incorporates the household ownership of different assets. We find that an increase in 1 standard deviation in the level of assets leads to a rise of 0.35 years in the highest grade attained across both countries, and this is independent of the impact of those assets on early cognitive ability and the health of the young child. We also tried adding

---

inputs. The presence of the adult height in this regression does not affect this relationship. This points towards a robust and strong relationship between the instrument and the endogenous variable, even after controlling for a variety of factors that might impact cognition formation in childhood. In comparison to column 1, in column 2 we add some second-grade, school-level characteristics as additional instruments.

interaction terms of the early life scores with assets and parent's education to these models. These variables were not significant and were, hence, omitted from the specifications reported here. Also, there does not seem to be a differential impact by gender, as indicated by the largely insignificant female dummy variable.

Other findings include evidence that being in an urban area seems to have a large and significant positive impact on highest grade attained in Senegal, but a more modest impact in Madagascar. This points toward an urban–rural divide in the education sector. It is hard to identify whether this is due to demand or supply side factors. It is possible that Senegal's more advanced and urbanized economy contributes to an imbalance in the amount and quality of education resources provided in rural and urban areas.

In the next set of tables, we use the same empirical methodology to estimate the impact of early cognitive ability and early childhood heath on human capital in adult life, as measured by three different outcomes: composite test scores (Tables 2a and 2b), math scores, and French scores (Tables 3a and 3b). The dependent variables in these regressions are standardized z-scores on the respective tests. The finding regarding the importance of early life ability is consistent with the results discussed earlier in terms of grade attainment. In Tables 2a and 2b, columns 1–4 show that there is a robust positive and significant relationship between early life cognitive ability and later life composite French and Math scores. Scoring 1 standard deviation above the mean on the second grade composite score leads to composite scores in 2012 that are 0.2 and 0.23 standard deviations higher in Madagascar and Senegal, respectively.

As expected, Tables 2a and 2b show that adult height has a positive impact on the composite scores in both countries, although the parameter is only significant in Madagascar. The lack of significance of the height parameter in Senegal is perhaps due to the sample size, or because of the possibility that health inputs play a more significant role in the human capital formation in Madagascar with its markedly worse health conditions. Results in Table 2a suggest that in Senegal having assets 1 standard deviation above the mean is related to an increase in composite test scores by around 0.1–0.15 standard deviations. Somewhat surprisingly, both mother's and father's education seems to have a negative impact on the composite test z-score, but these are not statistically significant. The parameters of living in urban area and the household having higher assets when the cohort member is in second grade both have significant positive impacts on composite test scores.

In contrast to Senegal, in Madagascar both mother's and father's education seems to have a positive and significant impact on the composite test z-score (Table 2b). One more year of education for either the mother or father raises the composite score by around 0.03 standard deviations. As in Senegal, living in a household with more assets when the child was in second grade, raises composite test z-score.

The IV specifications in columns 5 and 6 in Tables 2a and 2b suggest a positive impact of second-grade composite scores on adult life composite scores. Although the effect sizes are comparable across the two countries (around 0.2), the Senegal results are much more statistically significant than the Madagascar ones.

We observe similar patterns in the results in Tables 3a and 3b where the individual 2012 math and French test scores, rather than the composite score, are the outcomes of interest. Early life cognitive ability seems to have a large and positive impact on both math and French scores in Senegal, whereas they have a positive, but slightly smaller, impact in Madagascar. Adult height z-scores have a positive impact on both math and French scores in both Madagascar and Senegal, whereas they are statistically significant only in Madagascar. Family assets when the survey participant is in second grade and urban location have a positive impact on both test scores in Senegal. The assets when in second grade and mother's education have positive impacts on both adult math and French scores in Madagascar.

The results in Tables 3a and 3b are consistent with what we found with the composite score in Tables 2a and 2b. Here, we compare the effect sizes of the impact of the second-grade, post-test composite scores on different outcomes across the two countries. Tables 2a and 3a suggest that in the Senegal IV specifications, the impacts of composite second grade-scores on adult life test scores are the following: composite score (0.21–0.23), math (0.24), and French (0.19). The analogous results for Madagascar are: composite score (0.16–0.22), math (0.24), and French (21). We see that the impact on the adult math scores is slightly higher than the impact on the adult composite scores across the two countries. Also, what is commonly observed across both countries is that the effect on the French scores is the smaller than that on the math scores. Additionally, the assets in second grade have a significant impact on both the math and the French scores in both countries.

Additional results

To add to our analysis, we replicate the regressions discussed above using a slightly modified empirical strategy. Instead of using the composite math and French scores as the measure of early childhood ability, we use the French and math scores individually. We are motivated to do so to address the question of whether certain types of abilities are more important in affecting later life outcomes, a finding that has been reported elsewhere in the literature (Duncan et al 2007; Duncan and Magnuson 2011). Because math and French tests measure different kinds of abilities, these results might throw some light on different channels through which these effects could operate. In addition, this specification can be considered a robustness check to see if the impacts that we show above are driven by the specific way in which we measure cognitive ability.

Tables B1a–B4b show the results for the impact of the second-grade scores on the French and the math tests separately for each of the outcomes in both Senegal and Madagascar. Columns 1 and 3 in each of these tables report the OLS results of regressing the outcome of interest on the second-grade, post-test French and math scores, respectively. Note that these tables also include the same set of independent variables as the Tables 1a–3b.

In columns 1 and 3 of tables B1a and B1b, we see that there is a strong and positive association of highest grade attained with second-grade French and math scores. This effect persists even after the addition of childhood health inputs in these regressions. This is consistent with what we observed in our previous results (Tables 1a and 1b). In the IV regressions reported in column 2, we use the second-grade French pre-test and the other school characteristics listed earlier as instruments for the second-grade French post-tests. Column 4 reports analogous results using the second-grade math pre- and post-tests.

We find that the math scores have a strong and positive impact on highest grade attained in both countries. In Senegal, in the OLS specification, the impact of a 1 standard deviation rise in the second-grade math score leads to a rise in highest grade attained by about 1.35 years. The corresponding effect in Madagascar is 0.87 years. This effect size in each country is comparable to the impact of the composite score (Tables 1a and 1b) in both Senegal (1.4 years) and Madagascar (0.77 years). Similarly, the OLS specification in column 1 of Tables B1a and B1b tells us that the impact of the second-grade French test scores on highest grades are 1.15 (Senegal) and 0.42 (Madagascar), respectively. As compared to the math score results discussed above, these effects are much smaller and are not as close to the aforementioned composite test score results (Tables 1a and 1b).

Moving on to the IV specifications, in both countries the impact of the French test on highest grade attained is slightly weaker than that of the impact of the math test score. The IV results with the math test score (column 4 in tables B1a and B1b) are somewhat comparable to the IV results with the composite test score (columns 5 and 6 in Tables 1a and 1b). As discussed above with the OLS specification, the IV results for the French test impacts (column 2 in Tables B1a and B1b) are smaller than the IV results for the composite score results (columns 5 and 6 in tables 1a and 1b).

These results point towards a mechanism for math test scores measuring certain skills and abilities that have a significant impact on educational capabilities in later life. It is important to note that these results cannot be attributed to the instruments being weak, because in both countries the *widstat* (F-statistic) is well above the weak IV threshold of 10 and the Sargan J-statistic null is rejected.

Similarly, the results on other outcomes also vary by country. Results in columns 3 and 4 of tables B2a, B3a, and B4a suggest that in Senegal, the early life math score has a significant impact on 2012 composite, math and French scores in both the OLS and the IV specifications. Similar to the pattern noticed in the results for the highest grade attained, columns 1 and 2 of tables B2a, B3a, and B4a suggest that in Senegal, French test scores in second grade have a statistically significant positive impact in the OLS regressions, but it decreases in value and significance in the IV regressions.

The results for Madagascar are slightly different. The OLS regressions in columns 1 and 3 of tables B2b, B3b, and B4b suggest that the second-grade math scores (column 3) have a larger and more significant impact than second-grade French scores on test scores in later life (column 1) in the OLS specifications. However, in the IV regressions, the second-grade French score becomes significant, and the second-grade math score becomes insignificant. These results are a little surprising, based on prior literature, and based on the effects we observed in Senegal, we would expect the second-grade math scores to have a more significant impact than the French scores. One potential explanation could be that the instruments do not work well in the case of Madagascar. This point is especially borne out by the Sargan J-statistic p-value reported in column 4 of tables B2b, B3b, and B4b. These are the IV regressions where the math post-test is instrumented using the math pre-test and the other school-level characteristics. The null hypothesis of no correlation between the instrument and the error term can be rejected in these cases. This might be causing some issues with the IV estimation results.

Overall, the results point towards a trend where early life math scores seem to have a strong and robust impact on later life cognition. The effects are weaker for French scores, potentially implying that the math test may capture factors that are more powerful in determining long-term cognitive ability.

5. Conclusions

We find persuasive evidence of the impact of early life cognitive ability and health on educational outcomes and cognitive ability in later life, across two developing countries in Africa. Using different measures of early life cognitive ability in a human capital production function framework, we find that early life composite math and French test scores have large and significant impacts on highest grades attained and cognitive abilities of young adults, as measured by math and French test scores undertaken as adults. Additionally, child health, assessed by using adult height as a proxy, also has a significant impact on adult human capital, and these cognitive ability and health affects are robust to the inclusion of each other, indicating they are operating through different pathways. These results are robust to the addition of childhood inputs, captured by parental education and wealth measured at the time of entry into primary school. We also find that second-grade math scores have a higher impact on outcomes in later life than the second-grade French test scores. This alludes to the differential attributes that are captured by the math and the French tests.

These results imply large and robust impacts of early life ability endowment and argue for policies that target preschool-aged children who are lagging behind other children in terms of their ability and health status. Additionally, the results here also suggest that simple math and French tests could be used to identify the target programs, because along with height, they are strong measures of childhood deprivation, and we now know this deprivation will persist over time and translate into diminished ability as adults. It is important to note that although the analysis argues for early childhood interventions, it does not provide insights into the exact nature of the interventions required.

References

Harold Alderman, John Hoddinott, & Bill Kinsey (2006) “Long term consequences of early childhood malnutrition” Oxford Economic Papers 58 (3): 450-474. doi: 10.1093/oep/gpl008

Aubery & Sahn (2014): Cognitive achievement production in Madagascar: A value-added model approach, Unpublished manuscript

Behrman, J. R., Hoddinott, J. F., Maluccio, J. A., Soler-Hampejsek, E., Behrman, E. L., Martorell, R., Ramirez-Zea, M., and Stein, A. D. (2008). What determines adult cognitive skills? Impacts of pre-schooling, schooling and post-schooling experiences in Guatemala. IFPRI Discussion Paper 826, International Food Policy Research Institute

Victoria J. Bourne, Helen C. Fox, Ian J. Deary, Lawrence J. Whalley (2006) “Does childhood intelligence predict variation in cognitive change in later life?” Personality and Individual Differences 42 (2007) 1551–1559

Anne Case & Christina Paxson (2008) “Stature and Status: Height, Ability, and Labor Market Outcomes” Journal of Political Economy, 2008, vol. 116, no. 3

Cragg, J.G. and S.G. Donald (1993): “Testing Identifiability and Specification in Instrumental Variable Models,” Econometric Theory, 9, 222 – 240

Cunha, Flavio and James Heckman (2007). "The Technology of Skill Formation." American Economic Review, 97(2): 31-47.

CONFEMEN (1999). Les facteurs de l’efficacité de l’enseignement primaire: données et résultats sur cinq pays d’Afrique et de l’Océan Indien. CD-ROM.

Cunha, F., Heckman, J., (2008). Formulating, identifying and estimating the technology of cognitive and noncognitive skill formation. Journal of Human Resources 43 (4), 738–782.

Cunha, F., Heckman, J. J., and Schennach, S. M. (2010). Estimating the technology of cognitive and noncognitive skill formation. Econometrica 78:883–931.

Cunningham A. E., Stanovich K. E (1997) Early reading acquisition and its relation to reading experience and ability 10 years later. Developmental Psychology 1997 Nov;33(6):934-45.

Katja Coneus, Manfred Laucht & Karsten Reuß (2012) The role of parental investments for cognitive and noncognitive skill formation—Evidence for the first 11 years of life, Economics and Human Biology 10 (2012) 189–209

Duncan, Greg J.; Dowsett, Chantelle J.; Claessens, Amy; Magnuson, Katherine; Huston, Aletha C.; Klebanov, Pamela; Pagani, Linda S.; Feinstein, Leon; Engel, Mimi; Brooks-Gunn, Jeanne; Sexton, Holly; Duckworth, Kathryn; Japel, Crista (2007) School readiness and later achievement. Developmental Psychology, Vol 43(6), Nov 2007, 1428-1446. http://dx.doi.org/10.1037/0012-1649.43.6.1428

Feinstein, L. (2003), Inequality in the Early Cognitive Development of British Children in the 1970 Cohort. Economica, 70: 73–97. doi:10.1111/1468-0335.t01-1-00272

Peter Glick & Christopher Handy & David E. Sahn (2015) Schooling, marriage, and age at first birth in Madagascar, Population Studies, Taylor & Francis Journals, vol. 69(2), pages 219-236, July.

Glick, P. and Sahn, D. E. (2009). Cognitive skills among children in Senegal: Disentangling the roles of schooling and family background. *Economics of Education Review*, 28: 178–188.

Peter Glick & David E. Sahn (2010) "Early Academic Performance, Grade Repetition, and School Attainment in Senegal: A Panel Data Analysis," World Bank Economic Review, World Bank Group, vol. 24(1), pages 93-120, January.

Glick, P., Randrianarisoa, J. C., and Sahn, D. E. (2011). Family background, school characteristics, and children's cognitive achievement in Madagascar. Education Economics 19:363–396.

James J. Heckman & Stefano Mosso (2014). "The Economics of Human Development and Social Mobility," Annual Review of Economics, Annual Reviews, vol. 6(1), pages 689-733, 08. http://www.annualreviews.org/doi/pdf/10.1146/annurev-economics-080213-040753

Helmers, Christian & Patnam, Manasa (2011). "The formation and evolution of childhood skill acquisition: Evidence from India," Journal of Development Economics, Elsevier, vol. 95(2), pages 252-266, July.

Jones, S., Schipper, Y., Ruto, S., and Rajani, R. (2014). Can your child read and count? Measuring learning outcomes in East Africa. Journal of African Economies. Vol. 23, number 5, pp. 643–672 doi:10.1093/jae/eju009

Kleibergen, F. and Paap, R. (2006). Generalized Reduced Rank Tests Using the Singular Value Decomposition. Journal of Econometrics, Vol. 133, pp. 97-126.

Daniel LaFave & Duncan Thomas (2016) "Height and Cognition at Work: Labor Market Productivity in a Low Income Setting" NBER Working Paper No. 22290, May 2016

Le Thuc Duc (2011), Height and Cognitive Achievement of Vietnamese Children, World Development, Volume 39, Issue 12, December 2011, Pages 2211-2220

Francesca Marchetta & David E. Sahn, (2016) "The Role of Education and Family Background in Marriage, Childbearing, and Labor Market Participation in Senegal," Economic Development and Cultural Change, University of Chicago Press, vol. 64(2), pages 369 - 403.

Michaelowa, K. (2001). Primary education quality in francophone Sub-Saharan Africa: Determinants of learning achievement and efficiency considerations. World Development 29:1699– 1716.

Alan Sánchez and Abhijeet Singh (2016) Accessing Higher Education in Developing Countries:Panel Data Analysis from India, Peru, and Vietnam, Young Lives Working Paper 150, May 2016

Renu Singh and Protap Mukherjee (2015) Determinants of Successful Completion of Secondary Education- Evidence from Young Lives, Andhra Pradesh, Young Lives Working Paper 143, November 2015

Dean Spears (2012), Height and cognitive achievement among Indian children, Economics & Human Biology, Volume 10, Issue 2, March 2012, Pages 210-219

Todd, P. E. and Wolpin, K. I. (2003). On the specification and estimation of the production function for cognitive achievement. The Economic Journal 113:F3–F33.

Petra E. Todd and Kenneth I. Wolpin (2007) "The Production of Cognitive Achievement in Children: Home, School, and Racial Test Score Gaps," Journal of Human Capital, Vol. 1, No. 1 (Winter 2007), pp. 91-136

Tom S. Vogl (2014) "Height, Skills, and Labor Market Outcomes in Mexico" Journal of Development Economics 107 (2014) 84–96

World Bank (2016), Databank www.databank.worldbank.org (Accessed October 9, 2016)

Grajeda, Rubén, Jere R. Behrman, Rafael Flores, John A. Maluccio, Reynaldo Martorell and Aryeh D. Stein, 2005, "The Human Capital Study 2002–04: Tracking, Data Collection, Coverage, and Attrition," Food and Nutrition Bulletin 26:2 (Supplement 1), S15–S24.

Alderman, Harold, Jere R. Behrman, Hans-Peter Kohler, John A. Maluccio and Susan Cotts Watkins, (2001), “Attrition in Longitudinal Household Survey Data: Some Tests for Three Developing Country Samples,” Demographic Research 5:4 (November), 79–124

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., & Sexton, H. (2007). “School Readiness and Later Achievement” Developmental psychology, 43(6), 1428.

Duncan, G. J., & Magnuson, K. (2011). “The Nature and Impact of Early Achievement Skills, Attention Skills, and Behavior Problems”. Whither opportunity, 47-70.

Table 1a: Senegal: Impact of early life composite French and math scores on highest grade attained

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS(1)	OLS(2)	OLS(3)	OLS(4)	IV(1)	IV(2)
Grade 2 FM Post	1.538***	1.422***		1.401***	0.951***	0.800***
	(8.66)	(8.01)		(7.85)	(3.52)	(2.93)
Z-score height 2012			0.504**	0.382*	0.421*	0.486**
			(2.16)	(1.75)	(1.94)	(2.11)
Age in 2012		-0.577***	-0.565***	-0.576***	-0.573***	-0.568***
		(-7.80)	(-7.47)	(-7.80)	(-7.89)	(-7.32)
Female (=1)		-0.120	0.330	0.242	0.271	0.245
		(-0.37)	(0.78)	(0.62)	(0.69)	(0.60)
Mother Education		-0.0656	0.0619	-0.0373	-0.00547	-0.0630
		(-0.35)	(0.32)	(-0.20)	(-0.03)	(-0.34)
Father Education		-0.286**	-0.384***	-0.297**	-0.325**	-0.343***
		(-2.26)	(-2.86)	(-2.31)	(-2.55)	(-2.66)
Urban Dummy		1.208***	1.305***	1.164***	1.209***	1.274***
		(3.52)	(3.56)	(3.39)	(3.54)	(3.45)
Z-score Assets 95-96		0.301*	0.518***	0.273	0.352**	0.343*
		(1.77)	(2.85)	(1.61)	(2.01)	(1.80)
Constant	9.136***	24.45***	23.66***	24.15***	23.99***	24.33***
	(54.06)	(11.38)	(10.97)	(11.25)	(11.46)	(11.20)
Observations	447	447	447	447	447	404
r2	0.138	0.255	0.153	0.260	0.249	0.245
F	74.96	20.29	11.80	18.36	11.72	10.69
widstat					329.5	116.9
j					0	0.265
jp						0.876

Table 1b: Madagascar: Impact of early life composite French and math scores on highest grade attained

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	IV(1)	IV(2)
Grade 2 FM Post	1.190***	0.772***		0.766***	0.702*	0.684*
	(4.88)	(3.37)		(3.35)	(1.78)	(1.85)
Z-score height 2012			0.283*	0.270*	0.271*	0.272*
			(1.77)	(1.74)	(1.78)	(1.78)
Age in 2012		-0.069***	-0.069***	-0.070***	-0.070***	-0.070***
		(-7.44)	(-7.26)	(-7.65)	(-7.77)	(-7.75)
Female (=1)		-0.309	-0.0531	-0.0404	-0.0415	-0.0418
		(-1.05)	(-0.16)	(-0.13)	(-0.13)	(-0.13)
Mother Education		0.0905*	0.105**	0.0853*	0.0869*	0.0874*
		(1.84)	(2.14)	(1.75)	(1.80)	(1.81)
Father Education		0.122**	0.129**	0.115**	0.116**	0.117**
		(2.40)	(2.50)	(2.25)	(2.27)	(2.26)
Urban Dummy		0.271	0.506	0.247	0.268	0.274
		(0.77)	(1.47)	(0.70)	(0.74)	(0.78)
Z-score Assets 97-98		0.375**	0.415**	0.346*	0.352*	0.354*
		(2.03)	(2.21)	(1.85)	(1.88)	(1.91)
Constant	9.867***	26.82***	26.68***	27.10***	27.07***	27.06***
	(56.93)	(10.50)	(10.13)	(10.68)	(10.85)	(10.81)
Observations	333	331	331	331	331	331
F	23.83	34.82	32.19	33.29	31.77	31.99
r2	0.0793	0.331	0.308	0.336	0.336	0.336
widstat					129.6	74.54
j					0	0.0212
jp						0.884

Table 2a: Senegal: Impact of early life composite French and math scores on adult composite French and math score

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS(1)	OLS(2)	OLS(3)	OLS(4)	IV(1)	IV(2)
Grade 2 FM Post	0.41***	0.376***		0.373***	0.238***	0.212***
	(8.41)	(7.30)		(7.18)	(3.07)	(2.73)
Z-score height 2012			0.0805	0.0457	0.0584	0.0810
			(1.19)	(0.71)	(0.91)	(1.21)
Age in 2012		-0.11***	-0.11***	-0.11***	-0.11***	-0.11***
		(-5.33)	(-5.10)	(-5.30)	(-5.38)	(-5.15)
Female (=1)		-0.0310	0.0295	0.0104	0.0173	0.0114
		(-0.33)	(0.25)	(0.09)	(0.16)	(0.10)
Mother Education		-0.0969	-0.0575	-0.0936	-0.0805	-0.0862
		(-1.50)	(-0.90)	(-1.45)	(-1.27)	(-1.35)
Father Education		-0.0536	-0.087**	-0.0547	-0.0665	-0.0761*
		(-1.30)	(-2.00)	(-1.31)	(-1.58)	(-1.83)
Urban Dummy		0.239**	0.281***	0.235**	0.252***	0.262**
		(2.47)	(2.67)	(2.43)	(2.61)	(2.50)
Z-score Assets 95-96		0.0992**	0.156***	0.0955*	0.117**	0.105**
		(2.04)	(2.95)	(1.96)	(2.35)	(1.97)
Constant	0.0542	3.510***	3.454***	3.470***	3.464***	3.624***
	(1.15)	(5.54)	(5.49)	(5.46)	(5.64)	(5.74)
Observations	433	413	465	413	407	372
r2	0.167	0.245	0.126	0.246	0.230	0.227
F	96.28	16.69	8.681	15.03	8.186	7.969
widstat					343.3	121.8
j					0	0.308
jp						0.857

Table 2b: Madagascar: Impact of early life composite French and math scores on adult composite French and math score

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	IV(1)	IV(2)
Grade 2 FM Post	0.24***	0.145*		0.146*	0.161	0.217*
	(3.15)	(1.93)		(1.96)	(1.23)	(1.79)
Z-score height 2012			0.130**	0.131**	0.131**	0.131**
			(2.46)	(2.48)	(2.52)	(2.52)
Age in 2012		-0.013***	-0.014***	-0.014***	-0.014***	-0.0146***
		(-4.64)	(-4.77)	(-4.91)	(-5.04)	(-5.06)
Female (=1)		-0.145	-0.0168	-0.0128	-0.0123	-0.0108
		(-1.57)	(-0.16)	(-0.12)	(-0.12)	(-0.11)
Mother Education		0.0357**	0.0367**	0.0333**	0.0329**	0.0316**
		(2.32)	(2.39)	(2.16)	(2.14)	(2.04)
Father Education		0.0314**	0.0308**	0.0273*	0.0269*	0.0256*
		(2.11)	(2.01)	(1.79)	(1.77)	(1.69)
Urban Dummy		-0.0384	-0.00198	-0.0519	-0.0572	-0.0765
		(-0.35)	(-0.02)	(-0.48)	(-0.51)	(-0.70)
Z-score Assets 97-98		0.133**	0.132**	0.121**	0.120**	0.116**
		(2.39)	(2.37)	(2.20)	(2.17)	(2.10)
Constant	0.260***	3.529***	3.581***	3.713***	3.727***	3.779***
	(4.82)	(4.39)	(4.44)	(4.62)	(4.73)	(4.77)
Observations	309	307	307	307	307	307
F	9.893	17.76	18.20	16.68	16.68	17.07
r2	0.0400	0.238	0.239	0.252	0.251	0.249
widstat					111.4	66.09
j					0	2.128
jp						0.145

Table 3a: Senegal: Impact of early life composite French and math scores on adult French and adult math scores

	(1)	(2)	(3)	(4)
	OLS Math	IV Math	OLS French	IV French
Grade 2 FM Post	0.374***	0.236***	0.363***	0.186**
	(7.08)	(2.99)	(7.02)	(2.42)
Z-score height 2012	0.0475	0.0772	0.0430	0.0823
	(0.76)	(1.17)	(0.65)	(1.21)
Age in 2012	-0.117***	-0.120***	-0.111***	-0.115***
	(-5.31)	(-5.14)	(-5.09)	(-4.99)
Female (=1)	-0.0221	-0.0258	0.0393	0.0445
	(-0.20)	(-0.23)	(0.35)	(0.38)
Mother Education	-0.105	-0.0991	-0.0813	-0.0725
	(-1.58)	(-1.53)	(-1.27)	(-1.14)
Father Education	-0.0520	-0.0709*	-0.0557	-0.0790*
	(-1.25)	(-1.73)	(-1.33)	(-1.86)
Urban Dummy	0.195**	0.217**	0.265***	0.295***
	(2.01)	(2.06)	(2.73)	(2.81)
Z-score Assets 95-96	0.0919*	0.0978*	0.0962*	0.108**
	(1.87)	(1.82)	(1.96)	(2.04)
Constant	3.550***	3.699***	3.311***	3.466***
	(5.37)	(5.60)	(5.35)	(5.63)
Observations	381	347	381	347
r2	0.227	0.212	0.230	0.208
F	11.38	6.068	12.95	6.998
widstat		112.0		112.0
j		0.585		0.0846
jp		0.746		0.959

Table 3b: Madagascar: Impact of early life composite French and math scores on adult French and adult math scores

	(1)	(2)	(3)	(4)
	OLS Math	IV Math	OLS French	IV French
Grade 2 FM Post	0.155**	0.238**	0.144*	0.215*
	-2.09	-2.01	-1.93	-1.71
Z-score height 2012	0.115**	0.116**	0.130**	0.131**
	-2.18	-2.23	-2.36	-2.39
Age in 2012	-0.0139***	-0.0142***	-0.0131***	-0.0133***
	(-4.78)	(-4.95)	(-4.23)	(-4.34)
Female (=1)	-0.0989	-0.0949	0.0993	0.101
	(-0.97)	(-0.95)	-0.89	-0.92
Mother Education	0.0295*	0.0275*	0.0355**	0.0339**
	-1.93	-1.8	-2.24	-2.11
Father Education	0.0101	0.00806	0.0449***	0.0432***
	-0.67	-0.54	-2.85	-2.76
Urban Dummy	-0.154	-0.181*	0.0831	0.059
	(-1.49)	(-1.74)	-0.72	-0.52
Z-score Assets 97-98	0.134**	0.127**	0.106*	0.101*
	-2.35	-2.24	-1.83	-1.72
Constant	3.780***	3.869***	3.103***	3.169***
	-4.72	-4.9	-3.68	-3.79
Observations	312	312	309	309
F	11.92	12	22.39	23.1
r2	0.201	0.197	0.284	0.282
widstat		70.04		67.54
j		1.308		2.686
jp		0.253		0.101

Table 4a: Senegal First stage regression

	(1)	(2)	(3)	(4)
	IV FM	IV FM	IV French	IV Math
Grade 2 FM Pre	0.682***	0.681***		
	(18.15)	(18.22)		
Grade 2 French Pre			0.521***	
			(12.01)	
Grade 2 Math Pre				0.657***
				(16.78)
Z-score height 2012	0.0570	0.0894*	0.0924*	0.0809
	(1.28)	(1.91)	(1.75)	(1.61)
Age in 2012	-0.0287*	-0.0370**	-0.0274	-0.0326*
	(-1.86)	(-2.41)	(-1.65)	(-1.80)
Female (=1)	0.141*	0.155**	0.199**	0.0510
	(1.90)	(2.00)	(2.21)	(0.60)
Mother Education	0.0694**	0.0840**	0.0733*	0.0793*
	(1.98)	(2.31)	(1.67)	(1.95)
Father Education	-0.0401	-0.0299	-0.0442	-0.0147
	(-1.41)	(-1.07)	(-1.37)	(-0.47)
Z-score Assets 95-96	0.0456	0.0769**	0.105**	0.0719*
	(1.30)	(2.01)	(2.45)	(1.77)
Urban Dummy	0.0778	0.213***	0.314***	0.0527
	(1.07)	(2.83)	(3.85)	(0.60)
Dir- Years Exp		0.00499	0.000954	0.0104
		(0.77)	(0.13)	(1.47)
Years of experience of the teacher		-0.0196***	-0.0142***	-0.0212***
		(-4.85)	(-3.46)	(-4.28)
Observations	447	404	404	404
r2	0.452	0.491	0.332	0.438
fstat	329.5	116.9	55.47	98.04

Table 4b: Madagascar First Stage Results

	(1)	(2)	(3)	(4)
	IV FM	IV FM	IV French	IV Math
Grade 2 FM Pre	0.401***	0.365***		
	(11.39)	(9.92)		
Grade 2 French Pre			0.289***	
			(6.80)	
Grade 2 Math Pre				0.367***
				(9.96)
Director female (=1)		0.355***	0.496***	0.281***
		(3.70)	(4.78)	(2.74)
Z-score height 2012	-0.0419	-0.0489	-0.0593	-0.0248
	(-1.06)	(-1.27)	(-1.38)	(-0.57)
Age in 2012	0.00208	0.00189	0.00119	0.00177
	(0.88)	(0.80)	(0.47)	(0.71)
Female (=1)	-0.0854	-0.0736	-0.0550	-0.0606
	(-1.14)	(-0.99)	(-0.68)	(-0.74)
Mother Education	0.0192*	0.0127	0.00149	0.0229*
	(1.74)	(1.15)	(0.12)	(1.93)
Father Education	0.00803	0.00574	0.0107	0.00169
	(0.71)	(0.53)	(0.89)	(0.14)
Urban Dummy	0.184**	0.0658	0.221**	-0.107
	(2.39)	(0.82)	(2.54)	(-1.23)
Z-score Assets 97-98	0.0475	0.0186	0.0576	-0.0135
	(1.06)	(0.40)	(1.19)	(-0.27)
Constant	-0.556	-0.519	-0.326	-0.505
	(-0.87)	(-0.82)	(-0.47)	(-0.76)
Observations	331	331	331	331

Table 5a: Senegal Summary Statistics

	Observations	Mean	Std. Dev.	Minimum	Maximum
Highest Grade	447	8.97	3.82	0.00	15.00
Grade 2 French Pre	447	-0.10	0.87	-1.30	2.31
Grade 2 Math Pre	447	-0.10	0.92	-1.34	3.43
Grade 2 FM Pre	447	-0.08	0.88	-1.41	3.15
Grade 2 French Post	447	-0.11	0.93	-1.63	2.05
Grade 2 Math Post	447	-0.09	0.96	-1.96	2.03
Grade 2 FM Post	447	-0.11	0.92	-1.87	2.13
2012 French Z-score	381	0.00	1.00	-1.44	1.32
2012 Math Z-score	381	0.00	1.00	-1.29	1.71
2012 Math and French Z-score	381	0.00	1.00	-1.39	1.50
Z-score height 2012	447	0.02	0.87	-2.24	2.31
Female (=1)	447	0.42	0.49	0.00	1.00
Z-score for Assets in 95-96	447	0.05	1.00	-2.08	2.74
Urban Dummy	447	0.61	0.49	0.00	1.00
Age in 2012	447	23.80	2.04	16.00	29.00
Mother Education	447	4.30	0.77	2.00	9.00
Father Education	447	5.74	1.15	2.00	9.00
Dir- Years Exp	417	11.08	7.09	1.00	28.00
Years of experience of the teach	434	13.50	9.86	0.00	34.00
Z-score for Assets in 95-96	447	0.05	1.00	-2.08	2.74
=1 if school is in rural area	433	0.58	0.49	0.00	1.00

Table 5b: Madagascar summary statistics

	Observations	Mean	Std. Dev.	Minimum	Maximum
Highest grade completed 2012	333	10.04	3.22	1.00	15.00
French score 2012	311	0.27	0.94	-1.60	1.87
Math score 2012	314	0.31	0.90	-1.77	2.51
FM Score 2012	309	0.30	0.91	-1.79	2.32
Grade 2 FM Post	333	0.14	0.76	-2.22	1.64
Grade 2 French Pre	333	0.23	0.85	-1.81	1.91
Grade 2 Math Post	333	0.07	0.75	-2.28	1.28
Grade 2 FM Pre	333	-0.03	0.98	-2.38	2.15
Grade 2 French Post	333	-0.03	0.99	-1.82	2.32
Grade 2 Math Pre	333	-0.08	1.00	-2.77	1.51
Z-score height 2012	333	0.00	1.00	-3.35	2.57
Age in 2012	333	21.84	1.39	19.00	26.00
Female (=1)	331	0.53	0.50	0.00	1.00
Mother Education	333	5.62	3.65	0.00	17.00
Father Education	333	6.21	3.92	0.00	17.00
Urban Dummy	333	0.33	0.47	0.00	1.00
Z-score Assets 97-98	333	0.04	0.83	-1.98	3.74
Director female (=1)	333	0.27	0.45	0.00	1.00

Appendix

Table A1a: Senegal: OLS results of impact of second grade composite math & French pretest scores on different outcomes

	(1)	(2)	(3)	(4)
	High Grade	Math	French	Composite Score
Grade 2 FM Pre	0.649***	0.179***	0.145***	0.163***
	(3.35)	(3.19)	(2.62)	(2.93)
Z-score height 2012	0.475**	0.0720	0.0685	0.0711
	(2.06)	(1.09)	(0.99)	(1.05)
Age in 2012	-0.600***	-0.126***	-0.119***	-0.124***
	(-7.82)	(-5.46)	(-5.22)	(-5.43)
Female (=1)	0.405	0.0149	0.0724	0.0458
	(0.98)	(0.13)	(0.61)	(0.39)
Mother Education	0.0606	-0.0695	-0.0470	-0.0584
	(0.32)	(-1.11)	(-0.74)	(-0.93)
Father Education	-0.363***	-0.0779*	-0.0820*	-0.0811*
	(-2.65)	(-1.81)	(-1.82)	(-1.84)
Urban Dummy	1.283***	0.237**	0.307***	0.277***
	(3.53)	(2.28)	(2.97)	(2.69)
Z-score Assets 95-96	0.395**	0.118**	0.127**	0.124**
	(2.14)	(2.19)	(2.34)	(2.31)
Constant	24.34***	3.687***	3.419***	3.593***
	(11.38)	(5.68)	(5.54)	(5.72)
Observations	447	381	381	381
r2	0.173	0.140	0.141	0.143
F	11.56	6.493	7.157	7.086

Table A1b: Madagascar: OLS results of impact of second grade composite math & French pretest scores on different outcomes

	(1)	(2)	(3)	(4)
	High Grade	Math	French	Composite Score
Grade 2 FM Pre	0.282*	0.0600	0.0774	0.0639
	(1.75)	(1.12)	(1.52)	(1.23)
Z-score height 2012	0.242	0.119**	0.101*	0.119**
	(1.52)	(2.15)	(1.91)	(2.25)
Age in 2012	-0.0688***	-0.0126***	-0.0133***	-0.0140***
	(-7.23)	(-4.07)	(-4.53)	(-4.71)
Female (=1)	-0.101	0.0825	-0.120	-0.0306
	(-0.30)	(0.74)	(-1.15)	(-0.29)
Mother Education	0.100**	0.0380**	0.0322**	0.0357**
	(2.07)	(2.39)	(2.11)	(2.31)
Father Education	0.122**	0.0467***	0.0117	0.0290*
	(2.35)	(2.98)	(0.78)	(1.91)
Urban Dummy	0.397	0.114	-0.127	-0.0220
	(1.12)	(1.01)	(-1.24)	(-0.21)
Z-score Assets 97-98	0.385**	0.109*	0.136**	0.124**
	(2.03)	(1.84)	(2.39)	(2.22)
Constant	26.68***	2.977***	3.634***	3.588***
	(10.21)	(3.53)	(4.51)	(4.44)
Observations	331	309	312	307
r2	0.314	0.276	0.193	0.243
F	30.22	22.55	11.58	16.65

Table B1a: Senegal: Impact of early life French and math scores (separately) on highest grade attained

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	1.155***	0.633*		
	(6.25)	(1.82)		
Grade 2 Math Post			1.349***	0.959***
			(8.00)	(3.47)
Z-score height 2012	0.415*	0.522**	0.387*	0.454*
	(1.88)	(2.24)	(1.76)	(1.96)
Observations	447	404	447	404
r2	0.228	0.220	0.260	0.250
widstat		55.47		98.04
j		0.245		0.239
jp		0.885		0.887

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table B1b: Madagascar: Impact of early life French and math scores (separately) on highest grade attained

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	0.420*	0.504		
	(1.94)	(1.29)		
Grade 2 Math Post			0.873***	0.820**
			(4.25)	(2.16)
Z-score height 2012	0.285*	0.286*	0.252	0.254*
	(1.80)	(1.82)	(1.65)	(1.69)
Observations	331	331	331	331
F	29.76	29.58	35.85	33.53
r2	0.318	0.317	0.346	0.346
widstat		69.58		60.56
j		0.0295		0.0748
jp		0.864		0.784

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table B2a: Senegal: Impact of early life French and math scores (separately) on adult French and math composite scores

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	0.319***	0.174*		
	(6.07)	(1.75)		
Grade 2 Math Post			0.345***	0.254***
			(6.85)	(3.25)
Z-score height 2012	0.0543	0.0903	0.0486	0.0729
	(0.83)	(1.34)	(0.75)	(1.08)
Observations	381	347	381	347
r2	0.206	0.195	0.226	0.214
F	10.77	6.301	12.29	7.052
widstat		58.65		97.44
j		0.286		0.256
jp		0.867		0.880

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table B2b: Madagascar: Impact of early life French and math scores (separately) on adult French and math composite scores

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	0.0734	0.245**		
	(1.14)	(1.97)		
Grade 2 Math Post			0.173**	0.179
			(2.37)	(1.42)
Z-score height 2012	0.131**	0.134**	0.129**	0.129**
	(2.46)	(2.49)	(2.48)	(2.52)
Observations	307	307	307	307
F	16.07	16.63	17.09	16.75
r2	0.243	0.222	0.257	0.257
widstat		61.05		53.31
j		0.991		3.640
Jp		0.319		0.0564

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table B3a: Senegal: Impact of early life French and math scores (separately) on adult math scores

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	0.311***	0.203**		
	(5.83)	(2.02)		
Grade 2 Math Post			0.355***	0.274***
			(6.96)	(3.46)
Z-score height 2012	0.0567	0.0866	0.0495	0.0693
	(0.89)	(1.30)	(0.79)	(1.05)
Observations	381	347	381	347
r2	0.194	0.190	0.224	0.213
widstat		58.65		97.44
j		0.606		0.611
jp		0.739		0.737

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table B3b: Madagascar: Impact of early life French and math scores (separately) on adult math scores

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	0.0816	0.266**		
	(1.25)	(2.14)		
Grade 2 Math Post			0.180**	0.187
			(2.45)	(1.49)
Z-score height 2012	0.115**	0.119**	0.113**	0.113**
	(2.15)	(2.21)	(2.18)	(2.22)
Observations	312	312	312	312
F	11.30	11.89	12.07	11.46
r2	0.192	0.167	0.207	0.207
widstat		64.95		56.26
j		0.278		2.918
jp		0.598		0.0876

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table B4a: Senegal- Impact of early life French and math scores (separately) on adult French scores

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	0.319***	0.144		
	(6.09)	(1.46)		
Grade 2 Math Post			0.327***	0.229***
			(6.53)	(2.98)
Z-score height 2012	0.0507	0.0914	0.0466	0.0743
	(0.76)	(1.34)	(0.70)	(1.08)
Observations	381	347	381	347
r2	0.208	0.189	0.218	0.207
widstat		58.65		97.44
j		0.142		0.0906
jp		0.931		0.956

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table B4b: Madagascar: Impact of early life French and math scores (separately) on adult French scores

	(1)	(2)	(3)	(4)
	OLS	IV=All	OLS	IV=All
Grade 2 French Post	0.0819	0.241*		
	(1.27)	(1.91)		
Grade 2 Math Post			0.161**	0.188
			(2.23)	(1.46)
Z-score height 2012	0.131**	0.134**	0.128**	0.128**
	(2.34)	(2.38)	(2.35)	(2.38)
Observations	309	309	309	309
F	21.74	22.19	22.87	23.01
r2	0.277	0.261	0.288	0.287
widstat		61.85		54.28
j		1.639		4.047
jp		0.200		0.0443

Regressions include Age, parents education, asset z-score in second grade, female and urban dummy

Table C1a: Senegal balance checks

	Not in panel	Panel	Difference
Grade 2 French Pre	-0.13	-0.11	-0.02
Grade 2 French Post	-0.23	-0.11	-0.12
Grade 2 Math Pre	-0.16	-0.10	-0.06
Grade 2 math Post	-0.26	-0.09	-0.18**
Z-score Assets 95-96	-0.06	0.05	-0.11
Dir- Years Exp	10.67	11.08	-0.41
Director Male	0.95	0.97	-0.02
Female (=1)	0.40	0.42	-0.02
Rural School	0.56	0.58	-0.02
Years of experience of the teacher	10.27	13.48	-3.21***

Table C1b : Madagascar balance checks

	Not in panel	Panel	Difference
Grade 2 French Pre	-0.01	0.09	-0.10
Grade 2 French Post	-0.02	0.15	-0.18***
Grade 2 Math Pre	-0.00	0.03	-0.03
Grade 2 math Post	-0.05	0.29	-0.34***
Female (=1)	0.50	0.53	-0.03
Z-score Assets 95-96	-0.01	0.04	-0.04
Director Female	0.38	0.27	0.11***