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Starting Strong: Investigating the Importance of Early Academic Performance for Adult Human Capital

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Abstract

We use a production function approach to investigate the factors that determine young adults' human capital outcomes in Madagascar and Senegal. Our study relies on unique and comparable panel data spanning over 15 years for both countries. We find that second-grade students' test scores are strong indicators of their French and math skills, as well as their educational attainment in their early twenties. Moreover, we observe that the association between second-grade skills and later-life outcomes is stronger among girls than boys, and in math test scores compared with French test scores. Our results emphasise the critical role of performing well during the early school years, as it predicts long-term outcomes, especially for vulnerable populations such as girls.

Keywords: education, cognition, human capital, Africa
JEL classification: O12, C93, D62

1. Introduction

Cognitive skills have important implications not only for individual well-being (Heckman *et al.*, 2006) but also for economic growth (Hanushek and Woessmann, 2008, 2012; Hanushek, 2013). In this study, we investigate the determinants of grade attainment and academic performance among young adults on two African countries: Madagascar and Senegal. We focus on the role of second-grade skills, as measured by math and French test scores, in determining young adults' educational attainment and test scores. We also explore the influence of other factors, such as health, wealth and parental education on schooling and test score outcomes. To achieve this, we use two unique and comparable panel surveys from Madagascar and Senegal that tracked children from second grade to young adulthood. These cohorts were monitored over a remarkably long period of 15 years in Madagascar and 17 years in Senegal, which is unusual for survey data, particularly in the African context.

Our study contributes to the existing literature in economics and psychology, which examines the link between children's performance in elementary school and their academic performance later in life. Previous studies typically measured academic performance in terms of school attainment and test scores. We find a strong correlation between second-grade skills and later-life outcomes in both Madagascar and Senegal, which aligns with findings

from studies in other countries. For example, Feinstein (2003) demonstrated that cognitive scores obtained at around two years of age can predict educational qualifications at age 26 among British students, while Duncan *et al.* (2007) showed that math skills measured at the time of school entry are the strongest predictors of achievement in later life across six contexts. Cunningham and Stanovich (1997) found similar results in the United States, where they demonstrated that reading ability in the first grade was a strong predictor of multiple academic outcomes in the 11th grade. In addition, Bourne *et al.* (2007) used Irish data to show long-term persistence in cognitive abilities, and their analysis indicated that individuals with higher childhood cognitive ability experience relatively lower cognitive decline at older ages (70 years and above). Most of the related literature is based on data from developed countries, with a relative lack of evidence from developing countries, particularly from Africa. However, a recent exception is Das *et al.* (2022), who used panel data from multiple developing countries, including Ethiopia, India, Pakistan, Peru and Vietnam, and found that children with higher test scores at age 12 attained more years of schooling and were more likely to attend college.

Our study not only contributes to the literature on the persistence of academic skills from school entry to young adulthood but also addresses the question of how second-grade skills affect school progression. Specifically, we investigate whether young children who perform better on tests at the beginning of their schooling progress further into school. This could be explained by two possibilities: first, greater encouragement from teachers and parents leads to greater rewards for continuing education, and second, the presumption that children who display greater ability will progress further, regardless of external rewards and encouragement. Our study adds to the limited evidence on this topic from other low-income countries and is closely related to previous studies. Glick and Sahn (2010) found that skills in early primary school (second grade) in 1995–96 were strongly positively associated with school progression (measured through grade repetition) eight years later in Senegal. Similarly, Singh and Mukherjee (2015) found that skills in primary schools increased the likelihood of completing secondary schooling, using panel data from India. Glewwe *et al.* (2017), using data from rural China, found that students with higher levels of cognitive skills at ages 9–12 were more likely to be students at the ages of 17–21. Our analysis confirms these relationships but also includes the additional dimension of using datasets that span longer periods of time, allowing us to examine the relationship between second-grade test scores and human capital formation for a cohort of young adults in their early twenties.

Our study also probes the effects of early academic skills on other critical outcomes related to the transition from adolescence to young adulthood, namely employment, marriage, childbearing, and life skills. These outcomes are not only related to each other, but are also linked to the decision of when to leave school (Marchetta and Sahn, 2016). Previous studies show that test scores, especially mathematics tests, have a large effect on labour market outcomes (Rose, 2006; Joensen and Nielsen, 2009). However, there is limited evidence on this relationship in the African context. The same applies to the relationship between an individual's performance in their early years of schooling and how it shapes outcomes related to marriage and childbearing. Our findings show that in Senegal, there is a strong positive association between early life academic performance and life skills. Additionally, children with better performance in second grade are more likely to stay in school longer and start working at a later age. Despite these relationships, we do not find that better performance in the second grade is related to choices taken in early adulthood in terms of family formation: the associations between second-grade test scores with marriage and childbearing in early adulthood are weak in both countries.

To account for potential confounding factors, we control for family background, specifically parental education and wealth, which are known to be important predictors of children's cognitive development and educational attainment (Cunha and Heckman, 2007;

Todd and Wolpin, 2007; Cunha *et al.*, 2010; Glick *et al.*, 2011; Behrman *et al.*, 2014, 2017; Jones *et al.*, 2014; Marchetta and Sahn, 2016). Additionally, we consider the relationship between material well-being and, education and cognitive outcomes, as suggested by previous research (Cunha and Heckman, 2007, 2008; Todd and Wolpin, 2007; Helmers and Patnam, 2011; Schady *et al.*, 2015). However, in most studies from developing countries, income, expenditure, or wealth are measured contemporaneously with the outcome of interest. In contrast, we used wealth lagged 15 to 17 years, thereby mitigating concerns related to reverse causality. The unique nature of our data set also permitted us to assess these relationships while controlling for school characteristics.

We also investigate multiple sources of heterogeneity. First, we examine whether math or language skills have greater predictive power for later-life outcomes, which is essential to understanding the varying returns to investing in different early childhood skills. Duncan *et al.* (2007) have used data from the United States, Canada, and the United Kingdom to demonstrate that math skills at school entry are a stronger predictor of later achievement than language skills. We confirm this pattern in a vastly different context. Second, we examine whether our results vary by gender. We hypothesize that the relationship between early skills and academic performance would be stronger for the relatively disadvantaged gender. For instance, if society values boys' education more, early skills may matter less for boys if parents invest in their skill formation and education, regardless of their early skills. Conversely, only girls with high skills may benefit from greater investment in their human capital. However, the evidence from previous studies is inconclusive. Glewwe *et al.* (2017), using data from rural China, found no gender heterogeneity in the relationship between cognitive skills at ages 9–12 and school progression at the ages of 17 to 21. Glick and Sahn (2010) investigated student achievement in primary school and grade progression in middle school and found that gender differences were small in Senegal, although the relationship was slightly stronger for girls than for boys. Our findings suggest that early childhood skills matter more for girls, as there are larger negative consequences for girls who fall behind in the early grades in both Senegal and Madagascar.

We also explore heterogeneity in terms of household wealth levels to examine whether the association between early academic skills and later-life outcomes varies by wealth. Wealthier families may have greater financial resources to invest in their children's education regardless of their early academic performance. By contrast, poorer households may have more limited resources and, therefore, are more influenced by their children's early academic skills in terms of guiding their human capital investment decisions. If this was the case, lower-income households may demonstrate greater persistence between early childhood skills and later-life outcomes, a finding that would be consistent with Feinstein's (2003) observation that children who perform poorly in early life assessments from wealthier households tend to catch up or improve their performance later in life, whereas children from worse-off parents who perform poorly are less likely to catch up. Our findings contrast with this earlier work and suggest that in both Senegal and Madagascar there is a higher persistence in both math and French test scores among children from wealthier households. This may indicate that, in very poor countries, the opportunity cost of schooling may be higher, even among households with higher wealth, and that households with low wealth are unable to invest more in their children, regardless of their early performance.

Another distinguishing feature of our work is the fact that we study these research questions in two sub-Saharan African countries, both of which have similar French colonial legacies that had strong influence on their education systems, by using comparable datasets. To ensure the comparability of our results across Madagascar and Senegal, we apply Item Response Theory (IRT) to construct joint test score indices for both countries. Using these scores, we can compare performance across the two countries at two key points in time: early childhood and adulthood. This type of comparison of human capital formation, particularly

in developing countries, is scarce in the literature (Jones *et al.*, 2014; Schady *et al.*, 2015; Singh, 2016). Our study also differs from previous studies in that we examine a more extended period that covers the entire schooling experience.

Our analysis reveals a robust association between second-grade skills and human capital in young adulthood in both Madagascar and Senegal. Moreover, our findings suggest a persistent relationship between household wealth measured when the child is in second grade and schooling outcomes measured more than 15 years later, even after controlling for second-grade test scores, height, parental education and school quality.

2. Context

Our study examines the production of human capital among young adults in two poor sub-Saharan African countries: Madagascar and Senegal. Although these countries differ in many dimensions, they share several similarities. Both are low-income countries that struggle with low school attainment and primary school completion rates (World Bank, 2016). This is still the case despite significant improvements in primary school completion rates over the study period (1996–2012), from 40 to 59 percent in Senegal and from 31 to 70 percent in Madagascar. In the same period, gross enrollment rates in primary schools have also risen—in Senegal from 59 percent to 81 percent, and in Madagascar from 86 percent to 145 percent (World Bank, 2016). Additionally, in the 1990s, grade repetition and dropout rates were high in both countries (Michaelowa, 2001; Glick and Sahn, 2010). The similar challenges faced by these countries are likely a reflection of the fact that the educational systems in these countries are modelled after that in France, and the primary language of instruction is French. It is also noteworthy that despite the issues that these countries still face with school attendance and quality, there is at least strong evidence from Madagascar, which is more resource-constrained than Senegal, that schooling is associated with an increased level of cognitive skills (Aubery and Sahn, 2021).

Although the educational systems in Madagascar and Senegal are potentially similar, the opportunities and implications of background factors differ significantly between them. Madagascar, an island economy, experienced almost two decades of political turmoil, resulting in an average GDP per capita growth of zero during the study period (World Bank, 2016). By contrast, Senegal is one of the more dynamic economies in West Africa, with an average GDP per capita growth of 1.2 percent from 1995 to 2012. Madagascar also had a higher poverty headcount ratio of nearly 75 percent in 2010, while Senegal's headcount ratio stood at 47 percent in the same year (World Bank, 2016). Additionally, Madagascar has lower levels of intergenerational mobility in education and occupation than Senegal and most other African countries (Bossuroy & Cogneau, 2013; Azomahou and Yitbarek, 2016). Moreover, Glick *et al.* (2011) found that parents' education and schooling are important determinants of learning in Madagascar, whereas in Senegal, having better-educated parents or higher household resources has only modest benefits for academic performance, as shown by Glick and Sahn (2009). They found similar results regarding the impact of school-level variables on learning. Finally, Aubery and Sahn (2021) showed evidence of a widening skill gap in adolescence, reflecting that children who have accumulated more schooling have higher cognitive skills in Madagascar. However, the progression beyond primary school is limited, and dropout rates accelerate as children approach the end of primary school.

3. Data

In 1995–6 for Senegal and 1997–8 for Madagascar, the first survey round was conducted as part of the multi-country Program on the Analysis of the Conference of Francophone

Ministers of Education(PASEC 2016). Math and French tests were administered to children in both countries at the beginning and end of the second grade when they were between the ages of 7 and 10. The PASEC school-based sample included both urban and rural communities and was designed to be a nationally representative selection of schools throughout each country. If a community had multiple schools, one school was randomly selected as a part of the sample. However, it is important to note that the sample only included students enrolled in school and not the entire cohort of children in the relevant age range. Children who had never been enrolled in school or had left or dropped out of school before the second grade were excluded. Additionally, schools were only eligible for inclusion in the sample if they had a class size of at least 20 students, although this could include multi-grade classrooms. While almost all schools in Senegal met this criterion, the smallest and most remote communities in Madagascar were underrepresented in the sample.

In 1997–98 in Madagascar and 1995–96 in Senegal, a subset of children who participated in the PASEC surveys were surveyed again in 2012–13 as part of the Life Course Transition of Young Adults Surveys. These surveys collected data from young adults who were, on average, 22 years old in Madagascar and 24 years old in Senegal at the time of the survey. The children in this cohort were randomly selected from slightly less than half the original clusters included in the mid-1990s PASEC surveys[1]. Our final sample, which spans over 15 years, includes 333 and 447 children who were in second grade in the 1990s in Madagascar and Senegal, respectively[2].

3.1. Test score data

As previously mentioned, both math and French tests were administered in both survey rounds, but the tests were different for children and adults due to their different life courses. However, in each period, the tests in the two countries either had the same questions or a subset of common questions (see Appendix Tables A.1a and A.1b for more details). The presence of common questions allows us to construct test scores based on Item Response Theory (IRT), which models the probability of an individual correctly answering an exam item as a function of their latent ability and the characteristics of the question. Comparing tests with partial overlap of items using the commonly used measure of percentage of correct answers is not possible. Using the IRT method, the parameters are jointly estimated for the common items, allowing us to compare scores across countries for a given period[3]. This method enables us to conduct a descriptive comparison of test performance across the two countries, even when the tests were not identical[4].

Figures 1a–1c plot the cumulative density functions (CDF) of the test scores for both time periods, using the IRT estimates from the joint distribution of the test scores. First, we compare the test performance levels between the two countries. The distribution of composite scores for second grade (Figure 1a) shows that Madagascar's distribution first order stochastically dominates the distribution for Senegal, holding for both math (Figure 1b) and French (Figure 1c) scores separately. This indicates that the level of skills among children in the second grade in the 1990s was higher in Madagascar across the skill distributions. However, by 2012, there had been considerable convergence in the

[1] Selecting a subset of communities was necessitated by budgetary constraints at the time.

[2] The main reason for the smaller sample size in Madagascar is that fewer communities with PASEC schools were followed in Madagascar than in Senegal.

[3] Although we can compare the performance across countries, we cannot do so across time, because the tests administered to adults have no common items with the tests administered to children.

[4] The details of the extent of overlap between the tests in the two countries are given in Appendix A, along with the description of the IRT methodology.

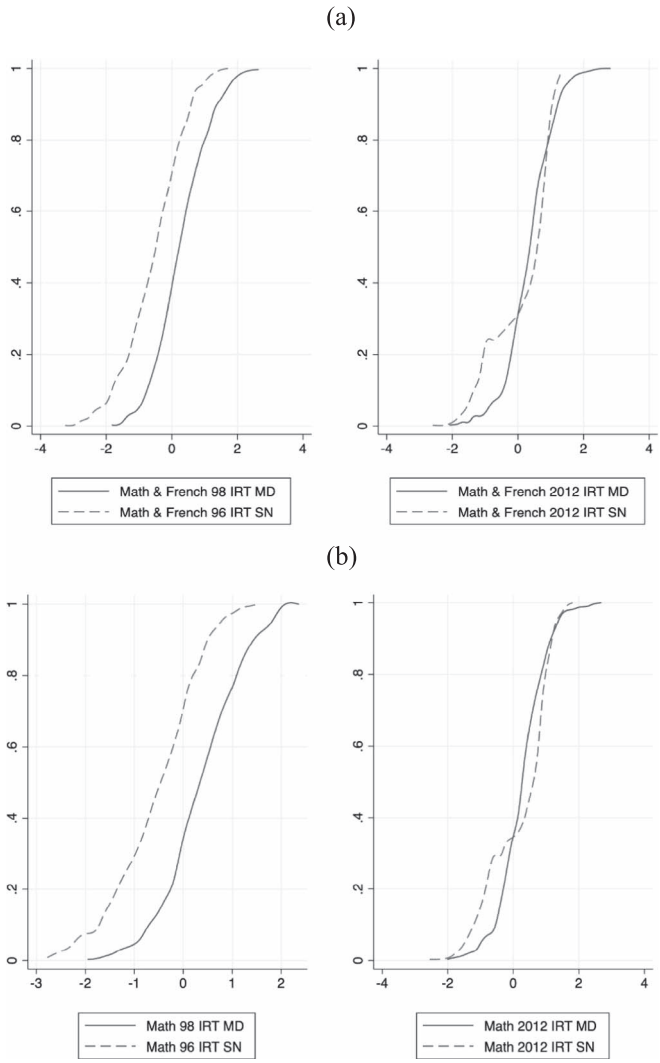
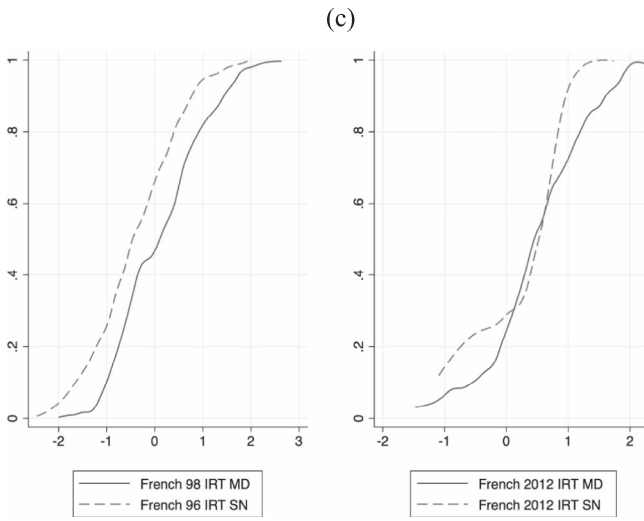


Figure 1. Cumulative Distribution Functions of (a) Composite Scores, (b) Math Scores and (c) French Scores

distribution of the scores across the countries. The right panels of Figures 1a–1c show that Senegal had caught up during their time in school and in early adulthood, and were no longer trailing Madagascar in terms of test score outcomes.

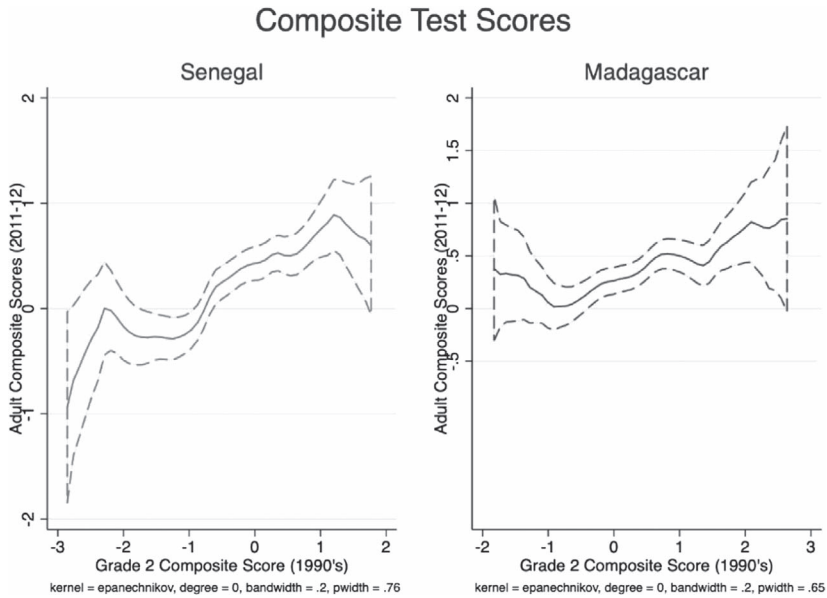
Second, we compare descriptively the relationship between the second grade and early adulthood scores. Figure 2 indicates that the relationship between second grade and early adulthood scores is stronger in Senegal than in Madagascar, as evidenced by the steeper slopes of the curves. Moreover, the narrower confidence bounds for Senegal suggest that this relationship is more precise in Senegal than in Madagascar.

While the IRT scores based on the joint distribution are valuable for descriptive comparisons of test scores between countries, in the regression analysis, we used IRT scores estimated separately for each country. This approach was taken because country-specific IRT scores provide a more precise estimate of country-specific measures of ability. Using



Notes: Test scores used are jointly estimated for each round for both countries using IRT. They are comparable across countries within each round.

Figure 1. Continued



Notes: Test scores used are jointly estimated for each round for both countries using IRT. They are comparable across countries within each round. Kernel: epanechnikov, degree=0, bandwidth=0.2, pwidth=0.65

Figure 2. Learning Progress Curves Composite Scores

separate IRT scores for each country also enables us to better model changes in test scores within and across countries over time.

3.2. Other outcomes

In addition to examining educational outcomes in young adult life, we also study the relationship between early-life test scores and employment, family formation and life skills. Specifically, we examine whether cohort members were employed in the 12 months prior to the survey, their current marital or cohabiting status, and the number of children they have. We measure life skills by administering questions that test individuals on everyday issues related to health knowledge and citizenship skills[5]. To create a life skills score, we aggregate the responses to these questions using item response theory (IRT)[6].

3.3. Descriptive statistics

The summary statistics for Senegal and Madagascar are presented in Appendix Table B.1[7]. The adult sample in Senegal had completed an average of 9 years of schooling, while in Madagascar, the average was 10 years. The Senegalese sample had a slight majority of males, whereas in Madagascar, the majority were females. The average age of the Senegalese sample was 24 years, which is slightly higher than the Malagasy sample, with an average age of 22 years. This age difference is consistent with the second-grade baseline data collected two years earlier in Senegal. Moreover, the Malagasy sample was on average 10 cm shorter than the Senegalese sample, which aligns with the findings from the DHS data (Subramanian *et al.*, 2011). The difference in height could be partially attributed to the distinct ethnic compositions of the populations, as the most significant ethnic groups in Madagascar are of Asian descent. Additionally, the original PASEC surveys conducted in the mid-1990s collected information on household characteristics, including infrastructure and asset ownership (18 items)[8]. We used factor analysis to create a household asset index, which weights each asset by the covariance structure of the asset vector. We used the first factor loading for analysis[9].

One concern with the dataset is attrition. We faced the challenge of finding the original children many years after the initial PASEC survey was conducted in the mid-1990s, more than 15 years later. This challenge was exacerbated by the extremely low living standards in these areas, economic volatility and continuous social transformations in the original communities surveyed. Despite our best attempts to locate as many of our sample individuals as possible, the attrition rates in both Senegal and Madagascar were just below 50 percent for the 17- and 15-year intervals, respectively.

To gain a better understanding of the impact of attrition on our analysis, we compare our cohort sample with the original PASEC samples. In Appendix Table C.1, we present a comparison of means for key variables between these samples. We find that in Senegal, the children in our panel had slightly lower second-grade test scores on average and belonged to

[5] Questions such as how to treat babies with diarrhea, why is it important to get vaccinated, and how to obtain a marriage license or a birth certificate were included in the life skills test.

[6] The life skills score in Madagascar is based on 15 questions, while in Senegal it is based on 9 questions. Of the 9 items in Senegal, 8 of them are the same as in the Madagascar life skills test.

[7] The sample sizes varies slightly, based on the dependent variable, due to missing observations in the test scores. The highest grade completed in Madagascar (Senegal) is available for 333 (447) individuals; the 2012 math scores are available for 318 (447) individuals; the 2012 French scores, for 312 (381) individuals; and the joint math and French test scores, for 310 (381) individuals.

[8] The asset index consists of exactly the same components in both countries. The index includes dummies for the following asset and household infrastructure variables: sofa, cooking pot, refrigerator, water tap, bed, electricity, oil lamp, car, bicycle, moped, wagon, video cassette player, TV, radio, kitchen or gas stove, charcoal or wood fireplace, toilet with running water, and plow.

[9] As an additional robustness check, we create the asset index using principal component analysis, following Filmer and Pritchett (2001). In Appendix Tables D.2a (Senegal) and D.2b (Madagascar), we run the core results of Tables 1a–4b with this alternative specification. The results remain unchanged.

households with slightly lower asset scores than the children not in the panel. Meanwhile, in Madagascar, the children in our panel were slightly younger than the overall sample and came from households with slightly less wealth, but we observe no systematic differences in test scores. The differences in Senegal arise from the fact that not all communities were reached during follow-up, rather than from attrition within a community (see Appendix Tables C.2 and C.3). To address concerns related to attrition and sample selection, we conduct a robustness check by estimating inverse probability weighted regressions. We use weights calculated based on the estimated probability of being in a community that was included in the follow-up survey, based on different characteristics in the baseline data. This exercise, discussed in detail in Section 5.5, demonstrates that our results are robust to attrition and sample selection-related adjustments. However, we want to emphasise that we do not claim our cohort to be representative of the entire population in the age group of the cohorts in the two countries, despite the checks intended to alleviate concerns over attrition and sample selection for follow-up[10].

4. Conceptual framework

In this section, we first present a simple theoretical framework of the cognitive production function, and subsequently we discuss the empirical framework that we use to estimate it.

4.1. Theoretical framework

We build upon the theoretical framework of Todd and Wolpin (2003, 2007) and Cunha *et al.* (2010), in which skills are developed over a period of time and are a function of inputs received[11]. Considering childhood (period 1) and adulthood (period 2) as two distinct time periods, the following is a simple illustration of the two-period mechanism pertaining to human capital accumulation:

$$Y_2 = f\Big(\beta_1 A_1(\mu_0) + \beta_2 P_1 + \beta_3 S_1\Big), \tag{1}$$

where the grade attainment Y_2 in Period 2 (adulthood) is a function of cognitive ability A_1, which is a function of genetics (μ_0) at the time of conception (period 0), while S_1 denotes the school inputs in period 1 (childhood), and P_1 denotes parental investments, including factors such as household wealth and the education of parents, in the same period.

If expressed in the form of skill accumulation, the model is

$$A_2 = g\left(\gamma_1 A_1\left(\mu_0\right) + \gamma_2 P_1 + \gamma_3 S_1\right), \tag{2}$$

in which we explain the stock of skills in Period 2, A_2, using the skill level in Period 1, A_1, as one of the explanatory variables. The rest of the terms are similar to equation (1).

The dynamic nature of this theoretical framework allows parental investments in a given period to be a function of the previous period's test score. Therefore, this framework allows parents to invest more (less) in better (worse) performing children, which could then have an effect on children's test scores in the next period (Glick and Sahn, 2009, 2010; Akresh *et al.*, 2012a, 2012b; Aubery and Sahn, 2021)[12]. This is relevant in resource-constrained

[10] Other panels of this type of duration and detail from developing countries, such as the Guatemalan studies (Grajeda *et al.*, 2005; Behrman *et al.*, 2014) 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).

[11] This framework is also the analytical point of departure of Aubery and Sahn (2021); Fiorini and Keane (2014), and Singh (2016).

[12] An important distinction here is that, although our model allows for such parental investments, we do not explicitly consider parental investments after the 2nd grade in our model on cognition as adults. Therefore, we

environments, such as Madagascar and Senegal, where child labour is prominent and the opportunity cost of schooling is high. Parents, who are assumed to be maximising their lifetime utility, therefore, must choose between short-term gains of their children working (the earning potential) versus the potential long-term benefits of education (Nordman *et al.*, 2022). In families with several children, as is most often the case in Senegal and Madagascar, the parents might be inclined to invest in the schooling of the best performing child, but this may not necessarily always be the case.

4.2. Empirical framework

The simplest empirical counterpart of Equation 1 is a reduced form model, which can be estimated using OLS:

$$Y_{i,2012} = \beta_0 + \beta_1 A_{i,1996} + \beta_2 HH_i + \beta_3 X_i + \gamma_j + \varepsilon_i, \tag{3}$$

where $Y_{i,2012}$ stands for the highest grade attained by the cohort member in 2012, and $A_{i,1996}$ stands for a measure of childhood skills, which in our case is measured using math and French scores at the beginning and the end of second grade (called pretest and posttest, respectively). The time index used in Equation (3) is 1996, which is the year corresponding to the Senegal data, while in the Madagascar data the first period corresponds to the calendar year of 1998. HH_i is a vector of household-level (time-invariant) inputs; γ_j are school fixed effects, corresponding to school j; and X_i denotes time-invariant control variables and adult height (measured in 2012). Height is a function of both health inputs received over the life course, particularly, *in utero* and in early childhood, as well as genetics (Martorell and Habicht, 1986). We include it in our model as a covariate, as evidence suggests that adult height is strongly related to outcomes in adulthood; thus, omitting height from the model could potentially lead to inflated coefficient estimates for other variables in the model (Case and Paxson, 2008; LaFave and Thomas, 2017).

Estimating Equation (2) leads to a very similar reduced form regression:

$$A_{i,2012} = \beta_0 + \beta_1 A_{i,1996} + \beta_2 HH_i + \beta_3 X_i + \gamma_j + \varepsilon_i \tag{4}$$

Our dependent variables $A_{i,2012}$are performances on French and math tests in 2012. We use these test score outcomes individually, as well as creating a composite score.

This setup is analogous to a value-added (VA) specification, in which current test scores are regressed on earlier period outcomes and other determinants. Although VA models have primarily been used to analyse skill acquisition from one grade to another, often focusing on estimating teacher and school characteristics and quality of learning, our paper differs from these analyses in an important way—we are interested in explaining skills in early adulthood, a time during which the cohort is no longer in school, using skills from a previous period (second grade)[13]. Since our empirical specification includes lagged inputs and lagged achievement, it can be thought of, therefore, as a 'combination of the cumulative and value-added models,' as described in Fiorini and Keane (2014, p. 805). It generalises the value-added (VA) model, which was preferred in Todd and Wolpin (2007), because it minimised the out-of-sample root mean squared error[14]. Although our framework is statistically equivalent to a VA approach with lagged inputs, but with one key

are not making a causal argument here; unlike Aubery and Sahn (2021), we do not estimate a value-added model that both includes lagged test scores and subsequent schooling inputs.

[13] See Fiorini and Keane (2014) for an overview of different specifications of VA models to explain cognitive skill formation for school-aged children with contemporaneous and lagged inputs.

[14] In addition, Fiorini and Keane (2014) also discussed data intensiveness of these procedures and the associated sample size issues in their analysis. We faced similar challenges but still ended with nearly the same sample size as their specifications.

difference—the time period between periods is longer (15–17 years) than in conventional VA models.

Our model accounts for school inputs by including school fixed effects. Each individual is assigned to the school they attended in second grade, and the fixed effects control for all time-invariant school-level factors, as well as time-invariant class-level unobservables, given that our data has only one class per school. These fixed effects also control for time-invariant community-level factors due to the one-to-one correspondence between schools and communities in our setting. As a result, our empirical specification compares outcomes in adulthood among children who attended the same school (and class) when in second grade, after controlling for other household and individual covariates. This approach ensures that the children were exposed to roughly the same socioeconomic and environmental factors in their childhood, making the comparisons more relevant.

To further reduce concerns about omitted variables, we include assets of the household, where the young adult lived when in second grade, parents' education variables from the second grade data, as well as individual-level characteristics such as height in early adulthood (a proxy for lifetime cumulative health status, predominantly influenced by the period from conception to 24 months of age), and the child's age and gender in our regressions.

We use second-grade math and French test scores to measure childhood academic ability. We use information on two sets of tests administered in second grade: the pretests conducted at the beginning of second grade (1995 in Senegal and 1997 in Madagascar) and the posttests administered at the end of second grade (1996 in Senegal and 1998 in Madagascar). These early-life test scores reflect cognitive ability, genetic factors, as well as household and school inputs received from the time of conception until the period when the second-grade test was conducted. We use the posttest score as the independent variable of interest in our specifications because these tests are comparable across the two countries. We also demonstrate the robustness of our findings by using the pretest as the key variable of interest (Appendix Table D.4) [15].

In our main analysis, we incorporate test scores that were derived using Item Response Theory (IRT). We generate three distinct sets of test scores for each round of testing in each country, which include math, French, and composite scores. Additionally, we investigate whether there are any differences in the predictive power of math and French test scores in second grade regarding adult skills. Previous research, mostly conducted in English-speaking countries, suggests that math ability may be a more potent predictor of later-life skills than language ability (Duncan *et al.*, 2007; Duncan and Magnuson, 2011). Therefore, we aim to explore whether this trend is applicable in our setting.

4.3. Correcting for measurement error

Test scores are susceptible to measurement errors because they depend on a student's one-time performance, which can be influenced by various factors related to the testing environment. This can result in a bias towards zero in the coefficient of the test score variable if these factors are idiosyncratic. To mitigate this issue, we adopt an instrumental variable (IV) approach. We utilise the pretest scores from second grade as an instrument for the posttest scores since we have data available for both the beginning and end of second grade.

[15] We also estimate a model with only lagged inputs, as well as a model that excludes lagged test scores, which in Todd and Wolpin (2007, 109) and Fiorini and Keane (2014, 805) are referred to as the 'cumulative model.' This model assumes that the lagged inputs incorporate the innate ability and unobserved inputs. Our estimations clearly show that this is not the preferred specification, as the lagged test scores were statistically significant. Another potential specification for studying the effect of lagged inputs on skills in early adulthood is to employ a fixed effects framework, as in Fiorini and Keane (2014). The underlying assumption is that the lagged coefficient of the test score is equal to 1 (Singh, 2016). Our results show that this is not a valid assumption, as the coefficient estimates are much lower, as in Singh (2016) and Fiorini and Keane (2014); but more importantly, this approach is not feasible due to the fact that we do not have time-varying inputs in our regressions.

This method has been employed in similar studies conducted by Ladd and Walsh (2002) and Andrabi *et al.* (2011). In our primary specification, we utilise the composite score of math and French as the primary independent variable of interest and account for measurement error by using the pretest composite score as an instrument for the posttest composite score. Our two-stage least squares (2SLS) model is expressed as follows:

$$TS^{post}_{i,1996} = \alpha_o + \alpha_1 TS^{pre}_{i,1996} + \alpha_2 HH_i + \alpha_3 X_i + \gamma_j + \tau_i \quad (5)$$

$$Y_{i,2012} = \delta_o + \delta_1 TS^{post}_{i,1996} + \delta_2 HH_i + \delta_3 X_i + \gamma_j + \theta_i, \quad (6)$$

in which posttest and pretest scores are denoted by $TS^{post}_{i,1996}$ and $TS^{pre}_{i,1996}$, respectively; γ_j denotes school fixed effects; HH_i refers to household-level inputs (parents' education and assets); and X_i denotes individual-specific controls.

The error term in our model might contain unobserved factors that are correlated with both our outcome of interest (such as later-life schooling) and childhood test scores, leading to endogeneity bias. It is important to note that the previously discussed instrumental variable strategy does not necessarily correct for this endogeneity bias and simply addresses systematic measurement errors. Thus, similar to other papers that have looked at childhood ability and how it affects outcomes in adult life, we relied on an important set of controls to at least mitigate endogeneity concerns. We note that several studies have compared value-added estimates with estimates from experimental or quasi-experimental analyses and concluded that the non-experimental estimates are unbiased when compared with experimental estimates (Angrist *et al.*, 2013; Kane *et al.*, 2013; Deming, 2014; Deming *et al.*, 2014). Moreover, the long duration of our panel mitigates concerns related to endogeneity, and to our knowledge, no research has covered such a large time span and addressed these concerns through an experimental design in which randomisation of ability was employed during the original time period. In our case, this was at least 15 years before the follow-up survey.

5. Results

5.1. Highest grade attained

Table 1 presents the relationship between second-grade test scores and the highest level of education completed by young adults in Senegal and Madagascar. In Senegal, a one standard deviation increase in the second-grade composite test score is associated with an increase in the highest grade completed by approximately 1.7 years (column 1). Similarly, in Madagascar, the corresponding coefficient is 0.7 years (column 3). Both coefficients are statistically significant at the 1 percent level. These regression results take into account school fixed effects, which control for time-invariant school-level factors.

In Madagascar, father's education has a positive relationship with grade attainment, while mother's education has a modest additional association[16]. In Senegal, the results suggest that mother's education has a positive relationship with grade attainment, but the relationship is not statistically significant. In contrast, assets are found to have a positive and significant association with education in Senegal, while there are no such significant associations in Madagascar. This could be due to the lower overall level of assets in households in Madagascar or the fact that assets do not have an independent relationship when parental education is included in the model, possibly because of the positive correlation between parental education and asset ownership.

[16] In Senegal, the average for mother's education is 1.3 years and for father's education is 2.7 years, so we use dummies for whether each parent has any education. In Madagascar, mothers and fathers have 5.6 and 6.2 years of education, respectively.

Table 1. Highest Grade Completed as a Function of Childhood Composite French and Math Scores

	(1) Senegal OLS	(2) IV	(3) Madagascar OLS	(4) IV
Second grade composite score	1.699***	1.390***	0.665***	1.285***
	(0.196)	(0.311)	(0.232)	(0.462)
Assets, 2nd grade	0.454	0.522*	−0.059	−0.119
	(0.303)	(0.289)	(0.248)	(0.242)
Mother's education	0.474	0.460	0.087	0.077
	(0.595)	(0.558)	(0.053)	(0.050)
Father's education	−0.288	−0.288	0.141***	0.137***
	(0.516)	(0.480)	(0.049)	(0.045)
Female	0.268	0.233	−0.116	−0.096
	(0.407)	(0.381)	(0.327)	(0.300)
Age in 2012, years	−0.499***	−0.498***	−0.711***	−0.733***
	(0.080)	(0.074)	(0.123)	(0.113)
Height in 2012, cms	0.042*	0.044**	0.019	0.019
	(0.023)	(0.021)	(0.020)	(0.018)
Total observations	447	447	333	333
R-squared	0.418	0.234	0.498	0.209
F-stat (instrument)		254.1		82.71

Notes: All specifications include School Fixed effects. Second grade denotes the year 1995–96 in the case of Senegal and 1997–98 in Madagascar. All test scores are constructed using country-specific IRT. Height is reported in centimetres. Age is reported in years. Mother's and father's education are continuous variables measured in years for Madagascar, and dummies for Senegal for any education. Household asset index is constructed using factor analysis. The F-stat denotes the Kleibergen-Paap Wald rk F statistic for weak instruments. Heteroskedasticity-robust standard errors in parentheses. $^{*}P < 0.10$, $^{**}P < 0.05$, $^{***}P < 0.01$.

As previously mentioned, measurement errors in the second-grade test score may lead to biased estimates. To mitigate this issue, we report results from an instrumental variable (IV) approach in columns 2 and 4 of Table 1. Here, we use the composite test score taken at the end of second grade as the main independent variable, which is instrumented with the score on the test administered at the beginning of second grade. The F-statistic for the excluded instrument exceeds the conventional threshold of 10 for weak instruments, at 10.83 in Senegal and 82.7 in Madagascar, indicating that the instrument is sufficiently strong. The IV coefficients of the association between composite test scores and grade attainment are similar in both countries, with estimates of 1.4 (Senegal) and 1.3 (Madagascar). These findings consistently suggest a significant positive relationship between second-grade test scores and future educational achievement in both countries.[17]

5.2. Test scores

5.2.1. Childhood composite test scores

We investigate the association between second-grade test scores and three different measures of adult test scores: a composite score of math and French, and math and French scores separately. Consistent with our previous findings on grade attainment, we observe a robust and enduring relationship between second-grade cognitive ability and later-life skills in both countries. Using the IV approach, we find that a 1 SD increase in second-grade composite test score is associated with an increase in adult composite test score of 0.27 SD (p-value <

[17] The idiosyncratic measurement error correction matters more in Madagascar than in Senegal. This may reflect the fact that the measurement error correction seems to work better with the pretest conducted in Madagascar than it does with that in Senegal, or that there might have been greater measurement error in Madagascar from the start. In addition, the difference in the correction from the IV can also stem from the fact that the questions in the pretests (used as the instrument) differed across the two countries.

Table 2. Adult Test Scores as a Function of Childhood Composite Test Scores, French and Math Scores

	(1) Senegal Composite	(2) Math score	(3) French score	(4) Madagascar Composite	(5) Math score	(6) French score
Second grade composite Score	0.267***	0.555***	0.208***	0.316**	0.349**	0.260*
	(0.071)	(0.118)	(0.069)	(0.134)	(0.139)	(0.142)
Assets, 2nd grade	0.154**	0.233**	0.165**	0.052	0.074	0.009
	(0.067)	(0.107)	(0.065)	(0.065)	(0.063)	(0.077)
Mother's education	−0.072	−0.071	−0.018	0.023*	0.021	0.028**
	(0.135)	(0.199)	(0.128)	(0.013)	(0.015)	(0.012)
Father's education	−0.017	−0.028	−0.047	0.016	−0.004	0.035***
	(0.117)	(0.164)	(0.117)	(0.012)	(0.013)	(0.011)
Female	0.060	−0.078	0.089	−0.025	−0.143	0.073
	(0.098)	(0.142)	(0.095)	(0.092)	(0.095)	(0.097)
Age in 2012, years	−0.062***	−0.105***	−0.058***	−0.139***	−0.129***	−0.106***
	(0.019)	(0.028)	(0.018)	(0.034)	(0.035)	(0.036)
Height in 2012, cms	0.007	0.012	0.007	0.005	−0.001	0.005
	(0.005)	(0.008)	(0.005)	(0.005)	(0.006)	(0.006)
Total observations	381	447	381	310	318	312
R-squared	0.166	0.194	0.140	0.118	0.071	0.133
F-stat (instrument)	232.4	254.1	232.4	57.8	60.01	57.39

Notes: All specifications are instrumental variables specifications, and include school fixed effects. Second grade denotes 1995–96 in the case of Senegal and 1997–98 in Madagascar. All test scores are constructed using country-specific IRT. Height is reported in centimetres. Age is reported in years. Mother's and father's education are continuous variables measured in years for Madagascar, and dummies for Senegal for any education. Household asset index is constructed using factor analysis. The F-stat denotes the Kleibergen-Paap Wald rk F statistic for weak instruments. Heteroskedasticity-robust standard errors in parentheses. $^{*}P < 0.10$, $^{**}P < 0.05$, $^{***}P < 0.01$.

0.01) and 0.32 SD (p-value < 0.05) in Senegal and Madagascar, respectively (columns 1 and 4 of Table 2). The results are similar for math (column 2 in Senegal and 5 in Madagascar) and French (column 3 in Senegal and 6 in Madagascar) scores separately in both countries. The coefficients are higher for math scores than for French scores, but the differences are not statistically significant when tested using a t-test. We also note that the coefficient estimate of the relationship between second-grade test scores and later-life education and test scores is generally higher for Senegal than for Madagascar, although these differences are not statistically significant[18]. Consistent with results in Table 1, household assets are strongly related with adult test scores in Senegal, while that is not the case in Madagascar. However, in Madagascar parental education matters more for later life test scores.

5.2.2. Other adult outcomes

Table 3 presents the relationship between second-grade test scores and life skills, still being in school, and employment status in the 12 months preceding the survey conducted in early adulthood. In Senegal, higher second-grade test scores have a strong positive association with still being a student in early adulthood, while having a strong negative relationship with the likelihood of being employed in the past 12 months (columns 1–3). This suggests that individuals who performed better in second grade are more likely to delay their entry into the labour market and stay in school longer, even into their early twenties. These results are consistent with the grade attainment findings in Table 1, but the individuals in school in 2012 (31 percent of the sample) are pursuing a much higher education level than the mean

[18] Results are available from the authors on request.

Table 3. Other Adult Outcomes as a Function of Childhood Composite Scores

	(1) Senegal Life skills	(2) In school	(3) Employed	(4) Madagascar Life skills	(5) In school	(6) Employed
Second grade composite score	0.360***	0.106***	−0.112**	0.155	0.025	−0.049
	(0.073)	(0.038)	(0.045)	(0.117)	(0.072)	(0.074)
Assets, 2nd grade	0.113	0.060	−0.059	0.018	−0.016	0.000
	(0.070)	(0.038)	(0.043)	(0.059)	(0.043)	(0.044)
Mother's education	−0.088	0.019	−0.033	0.001	0.019**	−0.019**
	(0.138)	(0.075)	(0.093)	(0.012)	(0.009)	(0.008)
Father's education	0.081	0.130**	−0.124*	0.018*	0.002	−0.007
	(0.110)	(0.059)	(0.068)	(0.010)	(0.007)	(0.007)
Female	−0.003	0.014	−0.333***	−0.066	0.032	−0.157***
	(0.088)	(0.051)	(0.053)	(0.090)	(0.056)	(0.048)
Age in 2012, years	−0.024	−0.069***	0.038***	−0.085***	−0.024	0.014
	(0.018)	(0.010)	(0.010)	(0.031)	(0.017)	(0.016)
Height in 2012, cms	0.005	0.001	−0.001	0.002	0.005	−0.005
	(0.005)	(0.003)	(0.003)	(0.005)	(0.004)	(0.003)
Total observations	381	445	447	322	327	328
R-squared	0.140	0.143	0.132	0.054	0.042	0.067
F-stat (instrument)	232.4	255.5	254.1	77.03	80.40	79.33

Notes: All specifications are instrumental variables specifications, and include school fixed effects. Second grade denotes 1995–96 in the case of Senegal and 1997–98 in Madagascar. All test scores are constructed using country-specific IRT. Height is reported in centimetres. Age is reported in years. Mother's and father's education are continuous variables measured in years for Madagascar, and dummies for Senegal for any education. Household asset index is constructed using factor analysis. The F-stat denotes the Kleibergen-Paap Wald rk F statistic for weak instruments. Heteroskedasticity-robust standard errors in parentheses. $^{*}P < 0.10$, $^{**}P < 0.05$, $^{***}P < 0.01$.

individual, who only has 9 years of schooling in Senegal. In Madagascar, the association between second-grade test scores and these outcomes (life skills, in school and labour market entry) is weaker (columns 4–6). However, a strong correlation between childhood academic performance and delayed employment and staying in school in Madagascar disappears when accounting for school fixed effects and background characteristics (columns 4 and 7 in Table E5b). In Madagascar, we find that mother's education is positively associated with being in school, and negatively associated with being employed (Table 3 columns 5 and 6). In Senegal, we find similar results, but the associations are significant for father's education (Table 3 columns 2 and 3). We also estimated a multinomial logit model to examine the decision of labour market entry and schooling jointly, and the alternative specification largely supports our findings (see Appendix Table D.5).

Table 4 examines the association between second-grade test scores and two additional outcome variables: marriage and number of children. We find that in Senegal, a higher second-grade test score is associated with a negative relationship with being married and having a lower number of children in 2012, but this relationship is not statistically significant. In Madagascar, there is a statistically significant negative relationship between test scores and the number of children at the 10 percent level (Table 4, column 4), while the other results are not statistically significant.[19] In terms of background characteristics, in Madagascar mother's education is associated with lower chances of being married/cohabitating (column 3 in Table 4), while in Senegal it is associated with higher chances of being married/cohabiting, and also with a higher number of children.

[19] An important caveat to this analysis is that the individuals in our sample are around 22–24 years of age, and hence, in all likelihood would not have completed their childbearing.

Table 4. Marriage and Fertility as a Function of Childhood Composite Scores

	(1) Senegal Married/cohabitating	(2) Children	(3) Madagascar Married/cohabitating	(4) Children
Second grade composite score	−0.014	−0.038	0.043	−0.170*
	(0.039)	(0.061)	(0.083)	(0.101)
Assets, 2nd grade	−0.038	−0.078	0.007	0.041
	(0.031)	(0.051)	(0.036)	(0.041)
Mother's education	0.162**	0.378***	−0.017**	0.003
	(0.072)	(0.143)	(0.008)	(0.010)
Father's education	−0.076	0.021	0.002	−0.006
	(0.061)	(0.100)	(0.008)	(0.008)
Female	0.295***	0.653***	0.143**	0.450***
	(0.048)	(0.083)	(0.056)	(0.069)
Age in 2012, years	0.036***	0.078***	0.039**	0.058**
	(0.009)	(0.017)	(0.020)	(0.025)
Height in 2012, cms	−0.001	−0.003	−0.002	−0.003
	(0.002)	(0.004)	(0.004)	(0.004)
Total observations	447	447	333	333
R-squared	0.200	0.267	0.062	0.146
F-stat (instrument)	254.1	254.1	82.71	82.71

Notes: All specifications are instrumental variables specifications, and include school fixed effects. Second grade denotes 1995–96 in the case of Senegal and 1997–98 in Madagascar. All test scores are constructed using country-specific IRT. Height is reported in centimetres. Age is reported in years. Mother's and father's education are continuous variables measured in years for Madagascar, and dummies for Senegal for any education. Household asset index is constructed using factor analysis. The F-stat denotes the Kleibergen-Paap Wald rk F statistic for weak instruments. Heteroskedasticity-robust standard errors in parentheses. $^{*}P < 0.10$, $^{**}P < 0.05$, $^{***}P < 0.01$.

While we observe a consistent relationship between childhood skills and young adulthood performance in both Madagascar and Senegal, we also find that the impact of second-grade skills on labour market entry differs between the two countries. This suggests that external factors such as economic conditions and supply-side factors may play a more significant role in determining the timing of school exit and labour market entry than the accumulation of math and language skills from second grade through young adulthood.

5.3. Robustness checks

We conduct several robustness checks to show that the findings are not sensitive to changes in different aspects of the empirical strategy. We tested the robustness of the findings by using an IV methodology developed in Lewbel (2012), in which the IV strategy exploits heteroskedasticity in the data, instead of imposing the standard exclusion restrictions in the two-stage least squares framework[20]. IV results are found to be robust to this alternative method and are presented in Appendix Table D.3. In the main specification, household assets are controlled for by constructing an index using factor analysis. In Tables Appendix D.2a and D.2b, results are presented where the household's assets are instead controlled for through an index constructed using principal component analysis (Filmer and Pritchett, 2001). The results are qualitatively similar to the main results in

[20] The method is applicable if there is at least one exogenous variable in the structural equation, and if the error terms are heteroskedastic. Each endogenous regressor is regressed on the set of exogenous variables. The residuals are used along with the demeaned set of exogenous variables to construct 'generated instruments.' We present results using the pretest and the generated instruments as instrumental variables, while the results with only the generated instruments are available on request. One of the advantages of this methodology is that the inclusion of an extra instrument allowed us to conduct the Sargan–Hansen overidentification test, as the generated instruments made the model overidentified. The J-statistic p-value showed that the null hypothesis of valid overidentifying restrictions holds for all outcomes across both countries.

Table 1. Finally, it is shown that the results are not sensitive to the functional form of the key dependent and independent variables of interest. First, the average of the second-grade post- and pre-scores is used as the main independent variable, instead of only the post-test score. The results remain robust to this alternative specification (Appendix Table D.4, columns 1 and 5). Second, the functional form of the outcomes is changed; instead of using the IRT score on the tests as the dependent variable, the z-scores of the percentage of correct answers are used as the dependent variable. This change yields very similar results (Appendix Tables D.1a and D.1b) to the ones presented in Table 2.

5.4. Heterogeneity

5.4.1. Childhood French and math scores

Here, we examine whether math and French tests have different associations with the outcomes of interest[21]. We conduct additional analyses to investigate whether there are differences in the associations between second-grade test scores and later-life skills for math and French tests, as these tests may potentially capture different types of abilities. Previous research conducted in predominantly English-speaking countries has suggested that math skills in childhood are stronger predictors of later-life skills than language skills (Duncan *et al.,* 2007; Duncan and Magnuson, 2011). Our results indicate that second-grade math scores are strongly and positively associated with highest grade attained in both Senegal and Madagascar (Table 5), which is consistent with our main results using the composite score (Table 1). In Senegal, a 1 SD increase in the second-grade math score is associated with an increase in highest grade attained by 1.4 years, while the corresponding coefficient estimate in Madagascar is 1.2 years (columns 1 and 5 of Table 5). Second-grade French tests also exhibit a positive relationship with later-life achievement across the two countries (Table 6), but the relationship is weaker in Madagascar.

We also demonstrate that the aforementioned association holds true for the composite score (columns 2 and 6), Math (columns 3 and 7), and French (columns 4 and 8) test score outcomes in Table 5 for Math and Table 6 for French. Interestingly, in the case of Madagascar, childhood math scores predict later-life French scores better than childhood French scores. For Senegal, adult French scores are equally well predicted by both childhood French and math scores.

Moreover, we examine whether the strength of the relationship between second-grade math scores and years of education attained differs significantly from the corresponding relationship between second-grade French scores and years of education attained. We use t-tests to compare the French and math test coefficients in both the OLS and IV regressions separately. However, we fail to reject the null hypothesis of the equality of the math and French coefficients in all cases in both countries[22]. In summary, there is some evidence that the math scores drive the strong relationship between composite scores (math and French) and later-life outcomes in Madagascar (Table E1b).

5.4.2. Gender differences

We also investigate potential gender differences in the relationship between childhood skills and later-life outcomes by estimating separate regressions for boys and girls. The results, presented in Figures 3a and 3b, reveal that the coefficient for childhood test scores is consistently larger for girls than for boys across all outcomes in both countries. This indicates that childhood performance may have a more enduring impact on later-life cognitive ability for girls, which implies that girls who fall behind in early grades may face

[21] The results are qualitatively similar if we were to use the pretest as the independent variable and the posttest as the instrument. The results are available from the authors by request.

[22] Results available from the authors on request.

Table 5. Adult Grade Attainment and Test Scores as a Function of Childhood Math Scores

	(1) Senegal Grade	(2) Composite	(3) Math	(4) French	(5) Madagascar Grade	(6) Composite	(7) Math	(8) French
Second grade math score	1.420***	0.266***	0.565***	0.210***	1.179**	0.356**	0.336*	0.355**
	(0.331)	(0.078)	(0.126)	(0.074)	(0.471)	(0.173)	(0.180)	(0.173)
Assets, 2nd grade	0.546*	0.153**	0.242**	0.163**	−0.090	0.053	0.079	0.007
	(0.286)	(0.068)	(0.106)	(0.066)	(0.238)	(0.064)	(0.060)	(0.079)
Mother's education	0.565	−0.055	−0.029	−0.005	0.087*	0.025*	0.023	0.029**
	(0.575)	(0.134)	(0.197)	(0.128)	(0.049)	(0.013)	(0.015)	(0.013)
Father's education	−0.313	−0.013	−0.038	−0.043	0.135***	0.015	−0.004	0.033***
	(0.493)	(0.120)	(0.169)	(0.120)	(0.045)	(0.012)	(0.013)	(0.012)
Female	0.410	0.093	−0.008	0.115	−0.038	−0.005	−0.128	0.094
	(0.392)	(0.101)	(0.145)	(0.097)	(0.306)	(0.094)	(0.095)	(0.099)
Age in 2012, years	−0.502***	−0.062***	−0.107***	−0.059***	−0.739***	−0.147***	−0.133***	−0.117***
	(0.076)	(0.019)	(0.028)	(0.018)	(0.114)	(0.035)	(0.037)	(0.039)
Height in 2012, cms	0.041*	0.007	0.010	0.006	0.017	0.005	−0.002	0.005
	(0.022)	(0.005)	(0.008)	(0.005)	(0.019)	(0.006)	(0.006)	(0.006)
Total observations	447	381	447	381	333	310	318	312
R-squared	0.208	0.138	0.174	0.112	0.210	0.112	0.093	0.099
F-stat (instrument)	192.0	169.5	192.0	169.5	51.28	45.16	45.84	44.94

Notes: All specifications are instrumental variables specifications, and include school fixed effects. Second grade denotes 1995–96 in the case of Senegal and 1997–98 in Madagascar. All test scores are constructed using country-specific IRT. Height is reported in centimetres. Age is reported in years. Mother's and father's education are continuous variables measured in years for Madagascar, and dummies for Senegal for any education. Household asset index is constructed using factor analysis. The F-stat denotes the Kleibergen-Paap Wald rk F statistic for weak instruments. Heteroskedasticity-robust standard errors in parentheses. $^{*}P < 0.10$, $^{**}P < 0.05$, $^{***}P < 0.01$.

larger negative consequences than boys. In other words, catching up from early cognitive deficits may be more challenging for girls than for boys in both countries.

To test the statistical significance of these gender differences, we conducted t-tests, which mostly failed to reject the null hypothesis of equality of coefficients across genders. This suggests that although there is a gender gap, it is not statistically significant in most cases. Additionally, we observe that higher test scores are associated with delayed labour market entry and delayed childbearing in Senegal.

5.4.3. Differences in household assets

We investigate whether differences in household assets during second-grade have an impact on the persistence of the relationship between childhood scores and later-life outcomes. To do this, we divide the sample into two groups based on whether household assets were above or below the (country-specific) median assets of the children in second grade. Our findings, presented in Figures 4a and 4b, suggest that possessing a higher level of assets in childhood is associated with greater persistence between second-grade test scores in both Madagascar and Senegal, as well as with being enrolled in school in 2012 in Senegal. This finding implies that children from relatively wealthier households are more capable of sustaining their better performance in second grade into their later-life outcomes, potentially through higher investments in education. An alternative interpretation is that children from economically disadvantaged households exhibit lower performance persistence, which may indicate their ability to overcome early disadvantages in test scores. However, caution is necessary when drawing firm conclusions, as the t-test for differences in the coefficients across the two groups is only significant in one case at the 5 percent level in Madagascar.

Table 6. Adult Grade Attainment and Test Scores as a Function of Childhood French Scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Senegal				Madagasacar			
	Grade	Composite	Math	French	Grade	Composite	Math	French
Second grade French score	1.597***	0.331***	0.647***	0.249**	1.696*	0.303	0.420*	0.208
	(0.411)	(0.099)	(0.157)	(0.097)	(0.876)	(0.215)	(0.232)	(0.222)
Assets, 2nd grade	0.493	0.153**	0.219*	0.166**	−0.122	0.059	0.077	0.017
	(0.304)	(0.069)	(0.112)	(0.066)	(0.254)	(0.067)	(0.067)	(0.077)
Mother's education	0.439	−0.081	−0.080	−0.024	0.075	0.024*	0.021	0.030**
	(0.557)	(0.137)	(0.204)	(0.129)	(0.053)	(0.013)	(0.016)	(0.013)
Father's education	−0.225	−0.014	−0.003	−0.045	0.141***	0.017	−0.003	0.036***
	(0.479)	(0.117)	(0.164)	(0.117)	(0.047)	(0.012)	(0.013)	(0.011)
Female	0.040	0.031	−0.155	0.066	−0.201	−0.046	−0.168*	0.058
	(0.386)	(0.099)	(0.145)	(0.095)	(0.312)	(0.092)	(0.097)	(0.097)
Age in 2012, years	−0.500***	−0.063***	−0.106***	−0.059***	−0.704***	−0.127***	−0.116***	−0.095***
	(0.075)	(0.019)	(0.029)	(0.018)	(0.117)	(0.034)	(0.035)	(0.036)
Height in 2012, cms	0.048**	0.008	0.014*	0.007	0.020	0.005	−0.001	0.005
	(0.021)	(0.005)	(0.008)	(0.005)	(0.019)	(0.006)	(0.006)	(0.006)
Total observations	447	381	447	381	333	310	318	312
R-squared	0.220	0.164	0.171	0.149	0.156	0.088	0.006	0.130
F-stat (instrument)	120.2	100.4	120.2	100.4	31.73	25.56	26.65	25.19

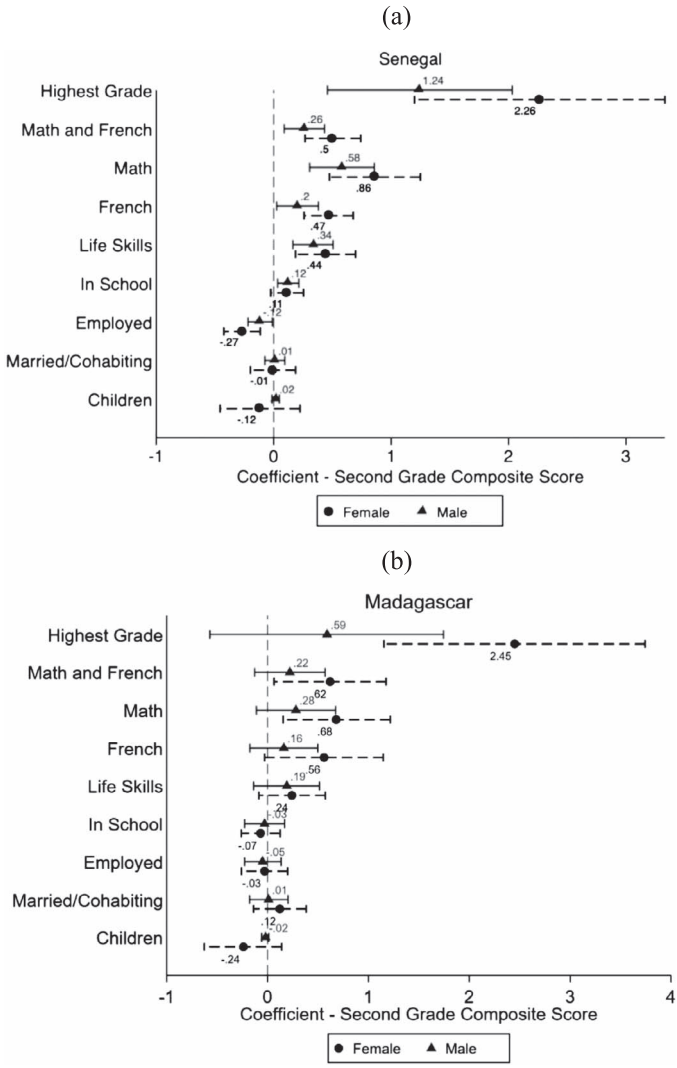
Notes: All specifications are instrumental variables specifications, and include school fixed effects. Second grade denotes 1995–96 in the case of Senegal and 1997–98 in Madagascar. All test scores are constructed using country-specific IRT. Height is reported in centimetres. Age is reported in years. Mother's and father's education are continuous variables measured in years for Madagascar, and dummies for Senegal for any education. Household asset index is constructed using factor analysis. The F-stat denotes the Kleibergen-Paap Wald rk F statistic for weak instruments. Heteroskedasticity-robust standard errors in parentheses. $^{*}P < 0.10$, $^{**}P < 0.05$, $^{***}P < 0.01$.

5.5. Accounting for attrition and sample selection

The attrition rates and sample selection discussed in Section 3 may raise concerns that our results are influenced by some form of sample selection. To address this issue, in Appendix Table C.1, we test for systematic differences between the panel that we use and the full sample of students at baseline. We conduct balance tests using school-level covariates from the PASEC surveys to check whether the school environments differ across the full baseline sample and the panel sample. We find modest differences, mainly in the Senegalese sample, which we control for by including school fixed effects in our specifications that account for all time-invariant, school-specific characteristics.

We also compare the means for observations in clusters chosen for follow-up with the full sample of students at baseline in Appendix Table C.2. We find that the results in Appendix Table C.2 are similar to those in Appendix Table C.1, and we find no systematic mean differences within the clusters that were chosen for follow-up (Appendix Table C.3). The balance checks for both countries presented in Appendix Tables C.1–C.3 demonstrate that any differences between the baseline PASEC sample and the panel subsample are driven by geographical differences, as only a subset of PASEC communities were included in the follow-up, and not due to differences between individuals that were reached and not reached within the selected communities.

To account for differences between the panel subsample and the full sample at baseline, we estimate Inverse Probability Weighted (IPW) regressions. The weights are obtained from a logistic regression using a dummy variable denoting the probability of being in the panel sample as the dependent variable, and a variety of household- and individual-level covariates from the full sample of the baseline data as covariates. We then use the predicted probabilities as weights in the main regression to check the robustness of our results to this adjustment. In Appendix Table C.4, we replicate the results of columns 1–5 in Tables E1a

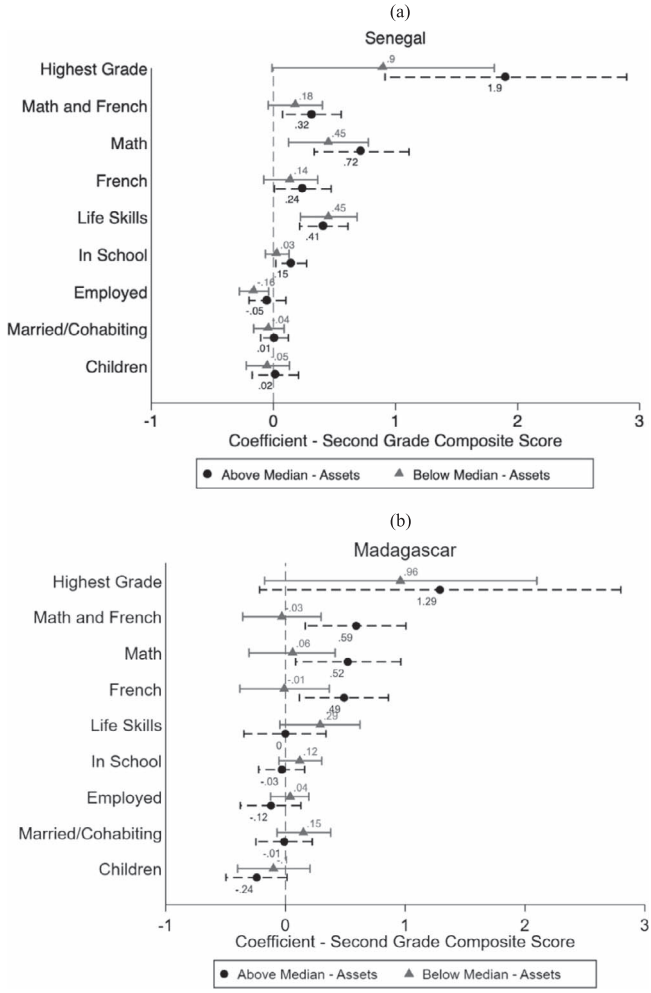


Notes: All coefficients are from the second stage of IV regressions. Second grade denotes 1995–96 in the case of Senegal and 1997–98 in Madagascar. All the specifications include school-level fixed effects.

Figure 3. (a) Gender Heterogeneity, Senegal. (b) Gender Heterogeneity, Madagascar

and E1b using the sample adjusted with the inverse probability weights. A comparison of Tables E1a and Appendix Table C.4 shows that the results for the highest grade obtained in Senegal are consistent in sign, statistical significance and value, even after the attrition adjustment. Similarly, a comparison of Tables E1b and C.4 indicates that the magnitudes are very similar in the case of Madagascar as well, and most of the statistical significance levels also remain the same. The pattern of the results is similar for the test score outcome variables (comparing Tables E2a and E2b with Table C4 columns 6–8). These findings demonstrate the robustness of our results to adjustments made for attrition and sample selection bias.

We conduct a similar analysis to examine attrition within the clusters chosen for follow-up. Specifically, we use IPW regressions (as previously described) with weights obtained



Notes: All coefficients are from the second stage of IV regressions. Second grade denotes 1995–96 in the case of Senegal and 1997–98 in Madagascar. All the specifications include school-level fixed effects.

Figure 4. (a) Asset Heterogeneity, Senegal. (b) Asset Heterogeneity, Madagascar

from a logistic regression that estimated the probability of being in the panel sample, given that the individual was in a community selected for follow-up. The results are shown in Appendix Table C.5. Overall, we can conclude that, although the selection of a subset of communities for follow-up introduced some differences between the panel and the full PASEC sample at baseline, our findings remain robust to this sample selection and even to accounting for the fact that only a fraction of the children in the revisited communities were included in the follow-up.

6. Conclusion

In this paper, we present evidence of a robust association between academic skills during childhood and early adulthood in two sub-Saharan African countries: Madagascar and Senegal. Using a human capital production function framework, we demonstrate that

composite math and French test scores, measured in second grade, have substantial and statistically significant positive relationships with the highest grade achieved, as well as math and French test scores in young adulthood in both countries that adhere to a similar education system influenced by their French colonial past. Notably, this relationship is stronger in Senegal compared with Madagascar. We also find that childhood math scores are better predictors of later-life cognitive outcomes than childhood French scores. These findings align with previous research indicating that certain types of abilities during childhood are more important for predicting human capital outcomes later in life. The results we report are robust to the addition of other childhood inputs, namely, parental education and asset levels, when the cohort member was in the second grade, as well as the inclusion of height and employing school fixed effects.

Additionally, we examine heterogeneity in relationships impacts along gender and wealth. Our findings suggest that girls who fall behind in early grades face more significant negative consequences than boys, indicating that catching up from early cognitive deficits may be more challenging for girls. On the other hand, we do not find evidence to suggest that children from relatively wealthier households are better able to maintain their better performances in second grade throughout their lives.

Additional to the academic outcomes, we also investigate the impact of early test scores on adult life skills and other life outcomes, such as labour market activity and family formation. We find that school performance in the early years has a persistent association with delaying labour market entry and prolonging studies in Senegal, but little association with family formation in either one of the countries. However, we faced challenges due to the length of time covered by the study and issues of attrition and measurement error. To address these potential issues, we employ techniques such as inverse probability weighted regressions and the instrumental variable method by Lewbel (2012).

The relationship between early academic skills and later outcomes is stronger in Senegal compared with Madagascar, which could be due to differences in economic growth and social mobility. Despite some differences in the populations and economic growth paths between the two countries, our study provides valuable insights because we have comparable data from the two countries spanning a long time period. Although we do not directly address policies to improve cognitive outcomes, our findings highlight the importance of early interventions to improve long-term outcomes for children.

Our study is unique in that we collected comparable longitudinal data on math and test scores from two sub-Saharan African countries over a period of more than 15 years, which is rare in this region. Although the socioeconomic characteristics of the two populations are different along several dimensions, and there was a marked difference in the two countries' economic growth path, our results are largely consistent. We find that the impact of early test scores on adult skills is generally strong and can persist across diverse contexts. Although we observe some differences between the two countries, both on the role of skill persistence and on the role parental characteristics, the consistency of our findings suggests that early academic performance has a powerful and persistent association with long-term human capital outcomes. This is especially relevant for sub-Saharan Africa, where longitudinal data on cognitive outcomes are rare in household surveys. Our study highlights the importance of early interventions to improve long-term outcomes for pre-school-aged children, particularly for those who may be lagging behind in skills, especially young girls who may have difficulty catching up from early academic disadvantage.

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Supplementary material

Supplementary material is available at *Journal of African Economies* online.

Data availability

All data to replicate the findings of the paper is provided in the replication package we have provided, and in which we have also included code to replicate the tables and figures in the paper. Any further queries can be directed to the authors (via email).

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