EFFECT OF ENTRY AGE ON SCHOOL PERFORMANCE: EVIDENCE FROM BOTSWANA

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Abstract
Literature indicates that students' relative age in school affects performance. This phenomenon has been studied in the developed world using strict school entry age for causal identification. Students born a few days beyond the school entry age, must enroll a year later than their peers. Such school entry age cutoffs are enforced in Botswana. This study analyzed Southern African Consortium for Monitoring Educational Quality (SACMEQ) dataset for Botswana to assess the impact of relative age on performance. In 2000 SACMEQ tests, older students performed .38σ worse than young ones on reading and .27σ worse on math while in 2006, relatively older students performed .63σ worse on reading and .34σ worse on math. Therefore older students perform worse than younger ones, in contrast to the developed world. It is hypothesized that older age in developing countries may be associated with poverty and hopelessness rather than maturity. While differences in age in developed countries elicit further teacher and peer investment and therefore long-term gains, in Botswana older age may be seen to elicit rejection and a long-term inefficient poverty trap.

KEYWORDS: Relative Age; Performance; Education; Test Scores; Self-Fulfilling Prophecy; Birth Date; School Entry Date; Entry Age; Regression Discontinuity; Instrumental Variables

Introduction

Many education systems have a strict cutoff date to enter school. For example, in Botswana, one has to be 6 years old by January 3rd to start school. This means that some students enter school older than others. If a child is born on January 5th, they will be too young by the cutoff date and must wait a full year to enroll. As a result, they will be around 20% older than a peer born on December 30th, who enrolled in school right away. Older students are likely to be more cognitively and physically mature on the first day of school. One would expect these pupils to outperform their younger peers. If this effect recedes as students grow older, it would not be a concern about the overall effect on learning and the resulting effect on the economy. However, it seems that students who start off school with an age advantage perform dramatically better even decades later.

Bedard and Dhuey (2006) examine 19 OECD countries and find that older students perform 4-12 percentiles higher in grade 4 than the youngest members in their grade, and 2-9 percentiles high in grade eight. Evidence from the developed world reveals a consensus on this trend. Ponzo and Scoppa (2011) in Italy, Srom (2004) in Norway and Sharp, George, Sargent, O'Donnell and Heron (2009) in the USA, Chile and the UK, Fredriksson and Öckert (2005) for Sweden, Smith (2009) for Canada and Puhani and Weber (2007) in Germany, show that older students do significantly better than their younger counterparts.

These results are robust to a shift in school entry dates, indicating that the difference is not a seasonal effect. Kawaguchi (2006) finds that students in Japan born after April 2nd do much better than peers born in March, when the starting date is April 1st. Henry (2013) compares UK students born in August to those born in September, the month of school entry, and finds that children born in the summer are relatively younger and score much lower.

Further literature indicates that these effects persist over time, though they diminish slightly. Crawford, Dearden and Greaves (2013) find that the older a pupil is in their class, the better they perform, with long-term effects on future employment opportunities. Kern and Friedman (2008) show that late entry into school is strongly associated with higher educational attainment and lower mortality risk

Theory suggests that investment in high-potential students early on will yield large educational returns later in life. Work by Cuhna, Heckman, Lochner, and Masterov (2006) provides strong evidence that skills gained early are complementary to later learning. Relative age, however, often determined by an arbitrary birth date, might cloud educator's ability to correctly identify high-potential students, instead mistaking relative age for ability. In tracking systems, which separate students by ability into more homogenous classrooms, this would lead to highly inefficient investments in older, yet lower-potential students.

In addition, there is a strong tendency for teachers to teach to the "top of the class." This is especially true in developing contexts, where only a small fraction of students pass into higher grade-levels, and teachers are assessed based on their passing rate. Teachers have a strong incentive to invest in higher-ability students, who are most likely to pass to begin with (Duflo, Dupas, Kremer, 2011). If teachers incorrectly identify high-potential students, disguised by relative age, this could result in wasteful investments. Moreover, there exists a natural tendency to teach to active students (e.g. students who raise their hands), who are often more confidant, mature and older. If early educational investments indeed translate to future learning, this might cause enormous inefficiency. Older students receive more attention. As a result, they do better, receiving even more attention, and performing even better. Under this paradigm, one early inefficient investment can result in an enormous opportunity cost where thousands of high-potential younger students might be left behind due to their relative age, determined by arbitrary birth dates and school entry cut-offs.

Inefficient human capital allocation can have devastating effects on the economy. A country's education level is of huge importance to its economic success. The economic literature suggests that differences in human capital endowments among countries are responsible for development gaps observed between industrialized nations and developing countries, thus, qualitative knowledge and skills acquired during school play a decisive role in influencing a country's growth (Hanushek and Woessmann 2008).

It is challenging to isolate the individual and causal effect of early maturity on outcomes since relative age is often endogenous. For example, motivated parents might hold students back to give them an advantage by entering school later. Alternatively, poorer parents might hold children back to work on the farm longer, putting them at an initial disadvantage. Additionally, older students might be held back as a result of poor performance. To this end, it is important to distinguish between *observed relative age* – one's current age in school -- and *assigned relative age* – the relationship between birth date and school entry that determines if a child will enter school relatively older.

Observed relative age masks other factors, such as wealth, geographic location, and motivation level, which can determine relative age. Older students might do better because they are richer and have motivated parents who held them back. If analyzed, observed relative age might mistakenly attribute discrepancies in performance to age, whereas other factors, such as wealth, are truly driving both age and performance.

Assigned relative age is, however, arguably exogenous. Whether a child was born a few days before or after the school entry date has little to do with wealth, geographic location, motivation or anything else. It is pseudo-random. However, as a result of the interaction between birth date and school entry cutoffs, it has a dramatic and precisely identified effect on relative age even ten years later. Thus, by comparing test scores of children with older or younger *assigned relative age* we can control for other factors that might influence test scores, uncovering the causal effect of age itself on performance.

The Case of Botswana.

Using a rich data set from the Southern African Consortium for Monitoring Education Quality (SACMEQ) in 2000 and 2006, we find that relatively older students in Botswana do dramatically *worse* than younger students. In the 2000 SACMEQ, students who were a year older performed .38σ worse on reading and .27σ worse on math. In 2006, the results were even more pronounced: students who were one year older performed .63σ worse on reading and .34σ worse on math. These results are robust to a policy shift, which decreased the entry age from 6 years to 5.5 years, affecting students taking the 2006 but not the 2000 SACMEQ.

These findings stand in stark contrast to literature from the developed world, where older students perform better than their younger counterparts. We hypothesize that this is a result of unusual and massive age distribution, where an 11-year old and an 18 year-old are often in the same sixth grade classroom in Botswana, and older students come from lower-income or less educated families. As opposed to western countries, where old age is associated with maturity and ability, in Botswana, older age signifies poverty, backwardness and inability.

Our results indicate that age has a negative and significant effect on performance in Botswana, even controlling for socioeconomic status, school type, and grade repetition. We further observe this trend when comparing students born just a few days before and after the school entry date, who share similar characteristics, but those born later enroll a year late and are therefore older.

It is likely that teachers, peers and students internalize a negative stigma towards age. In addition to baseline negative effects of poverty and lower-ability on performance, teachers, provide older students less attention, perceiving them as destined to fail, and older students themselves aim lower. This leads to a self-fulfilling prophecy downward. This self-fulfilling prophecy downward has a massive opportunity cost: older high-potential students are being left behind, while younger, low-potential students are inefficiently invested in.

Theoretical framework

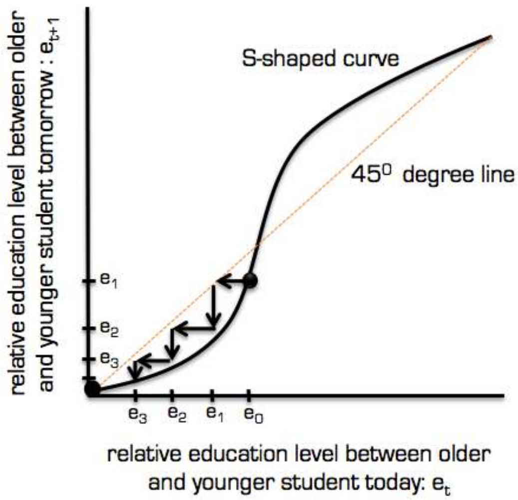
In the self-fulfilling prophecy, initial levels of human capital endowment perpetuate final outcomes. This indicates that if older students in Botswana start school at a disadvantage based on their relative age, they are destined for failure, due to teacher perceptions, internalized self-efficacy, and entrenched tracking systems. This world can be described by Figure 1.0, where relative education levels between older and young students today, e_t, has an S-shaped relationship with relative education levels between older and younger students tomorrow, e_{t+1}.

For low levels of initial relative education, $e_{0,}$ there is a low return to relative education, $e_{1,}$ since students are neglected and receive low investment. For low e_0 the curve is flat. For higher initial relative education levels, $e_{t,}$ students are deemed gifted, and receive a significant boost in attention, become more able, benefit from even more attention and special programs, and thus receive even greater relative education, e_{t+1}. For medium e_t the curve is steep. At some point, being superbly well educated has diminishing returns, since there is a cap on how much investment a child can receive. Einstein can only get so much smarter. For high $e_{t,}$ the curve becomes flat again. This produces our S-shape relationship between relative education today, e_t, and relative education levels tomorrow, $e_{t+1.}$

In order to determine the dynamic equilibrium, we trace the curve. If we start at a low relative education level, say e_0, prior to where the S-shaped curve intersects the 45-degree line, we cycle downwards. Here an e_0 initial relative education yields e_1 relative education tomorrow. Consider a student who entered Standard 1 relatively older, and therefore, in the Botswana context, at a disadvantage. The child is neglected, and receives some level e_1 education, which is lower than the child's relatively younger peers. Next year the child is in Standard 2, starting with an education level of $e_{1.}$ We trace e_1 back from the y-axis to the x-axis using the 45-degree line where x=y, since e_1 has now become education today, one year later. Now an e_1 relative education level in Standard 2 yields e_2 relative education level in Standard 3, which is again lower than the child's younger peers. Next, we trace Standard 3 to Standard 4, where we start with e_2 relative education levels in Standard 3. This yields relative education level e_3 in Standard 4, which is lower still than the students relatively younger peers, and the cycle downward continues, as younger students pull away in terms of performance and outcomes.

We adapt the self-fulfilling prophecy model, formalized by Debraj Ray (2001) as the "poverty trap", to the instance of relative education levels. This provides a hypothesis for why students who enter school at a relatively older age, even if there exists no significant difference between their younger counterparts born just a few days before them, do significantly worse later in life. Initial disadvantages propagate themselves, yielding significant long-term consequences.

Figure 1.0: The Self-fulfilling Prophecy



In this paradigm, birth dates determine when a child enters school, which in turn determines a child's relative age, which due to teacher perceptions and student self-efficacy, as well as tracking systems, effects initial educational investment, which ultimately determines educational outcomes.

Methodology

We employ a variety of quantitative methods to determine the effect of relative age on school performance. First we run a standard ordinary least squares regression (OLS) to determine the correlation between age and performance. Our model takes on the following specification:

$$(1) \quad Y_i = \alpha + \beta X_i + \varepsilon_i$$

where Y_i is our dependent variable, test scores, α is our intercept, β our coefficient describing the relationship between being one month older and school performance, X_i is our independent variable, age in months, and ε_i is our error term.

However, this specification suffers from significant bias. Socioeconomic factors such as wealth and parent education might play a large role in determining *both* whether you enter school at an older age as well as your performance. For example, if older students come from more disadvantaged backgrounds in Botswana, since students are kept on the farm as long as possible, even if β were negative, this might not mean that older age necessarily *causes* worse performance. Instead, it could mean that older students tend to be poorer, and being poorer causes you to perform worse. Here, age masks the underlying factor driving performance: wealth. To determine the causal effect of relative age on performance, we control for such variables, which might drive both relative school age and performance. Below we describe this model:

$$(2) \quad Y_i = \alpha + \beta_1 X_1 + \beta_i X_i + \varepsilon_i$$

where β_1 represent the relationship between X_1, relative age in months, and Y_i, test scores; and β_i represents the relationship between X_i, a vector of control variables such as number of livestock and the incidence of grade repetition, and Y_i, test score outcomes. This estimation brings us a step closer to identifying the unique effect of relative school age on performance.

Even in the above specification, however, there are a number of control variables that are unobservable, such as student and parent motivation, and data we simply don't have. To this end, this estimation suffers from large omitted variable bias. In order to best estimate the causal effect of age on performance, we exploit the interaction between strict school entry cutoffs in Botswana and birth date. If a child is born a few days after the entry date, they miss the deadline, and wait a full year to enroll, making them around 20% older upon entry than peers born just a few days before the cutoff. Thus, birth date significantly affects relative age in school.

At the same time, birth date is entirely unrelated to potential confounding factors such as wealth, religion, gender, education, or motivation. None of these factors vary systemically depending on whether you were born on January 3rd versus December 30th. Birth dates effect relative age, independent from any other variable. This variable, heron referred to as *assigned relative age*, is thus unbiased. To this end, we can use *assigned relative age* to estimate the unique and causal effect of age on performance. Below we describe this model:

$$(3) \quad Y_i = \alpha + \beta X_i + \varepsilon_i$$

Where: X_i *is* a dummy variable taking on the value 0 or 1 depending on whether you where born right before or right after the school cutoff date, and Y_i is our dependent variable, test scores. This technique leverages a discontinuity around the entry date to generate an unbiased estimate of the effect of age on performance.

However, if school entry dates are enforced, but not strictly, this discontinuity might be fuzzy rather than sharp. This is highly plausible given that schools often allow certain students to enroll later or earlier on a case-by-case basis. If the discontinuity were sharp, students born after the cutoff would be around 11 months older than students born right before. However, we find that, on average, students born after the cutoff are 6 months older than students born just before in 2000, and 3 months older in 2006, significant at the 1% level.

Table1: The effect of being born just after cut-off on relative age

The Effect of Being Born Just After the Cut-off on Relative Age

Variable	Age in Months (2006)	Age in Months (2000)
Born_After_Cutoff	3.029***	5.94***
Constant	161.34	157.09
P-value	0.00	0.00
T-Statistitic	13.77	51.3

*** Statistically significant with 99% confidence

This indicates that a discontinuity exists and is highly significant, but is fuzzy.

To this end, we specify an alternative model which takes into account the fuzzy relationship between being born after the cutoff and the resulting effect on relative age (e.g. a 3 month increase in age). This model takes the following form:

$$(4) \quad Y_i = \alpha + \beta Z_i + \varepsilon_i$$

where, Z_i, *assigned relative age* is an instrumental variable for *observed relative age*, X_i. In particular, we construct Z_i as a dummy variable taking on the value 0 or 1 depending on whether

you where born before or after the school cutoff date, and X_i as a continuous variable capturing one's age in months.
This technique utilizes both a discontinuity in performance around the school entry cutoff, as well an instrumental variables approach to proxy relative age via birth date. The result is a credibly causal estimate of the effect of age on performance.

We run our analyses using both the 2000 and 2006 SACMEQ data. By using a longitudinal dataset, we provide evidence that the effect of age on performance holds across any independent instance in time.
We further exploit a policy shift, which was passed in parliament in 1994, took affect after 1995, and shifted the school entry date from 6 to 5 ½. This change affected students born in 1993-1994, who enrolled in school in 2000, by the time the policy was in full effect, but *did not* affect students born before the school entry date in 1987, who enrolled in school in 1994, right before the new policy was implemented. The average student born in 1987 enrolled in 1994, and took the SACMEQ in Standard 6 in 2000. Students born in 1993-1994, enrolled in 2000, and took the SACMEQ six years later in 2006.

This policy shift allows us to compare the average student born in 1987, who wasn't affected by the policy, and took the SACMEQ in 2000, and an average student born in 1993-1994, who was affected by the policy, and took the SACMEQ in 2006. If our performance discontinuity is robust to this policy shift, that is, we observe the discontinuity shift six months forward from January to July to accommodate for earlier school entry, this provides compelling evidence that relative school age has a causal effect on performance, regardless of other variables, chance, and seasonal effects.

Data

We assemble a longitudinal dataset on educational outcomes in Botswana. Our data draws on performance indicators from SACMEQ 2000 and SACMEQ 2006, collected at 6-year intervals with the assistance of Botswana's Ministry of Education and the Botswana Educational Research Association (BERA).

We include explanatory variables such as birth date, assigned relative age, and observed relative age. We also include control variables such as parent education levels, number of livestock, wealth, number of books at home, prevalence of running water at home, school type, and the incidence of grade repetition.

Our 2000 data set (SACMEQ II) spans 170 primary schools in Botswana, 420 teachers, and 3,332 students; our 2006 data set (SACMEQ III) covers 160 primary schools, 386 teachers, and 3,869 students. The data covers all seven primary education regions in Botswana: Central North, Central South, North, South, South Central, West and Gaborone. Both private schools and public schools are included. Target students are Standard 6 pupils in primary school. All study participants were randomly chosen for surveying, ensuring the data is representative of the country as a whole.

It should be noted that SACMEQ is a standardized assessment spanning 15 countries in the Southern and Eastern African region. The dataset thus allows for meaningful cross-country comparisons. Future analyses might compare countries in the region with high versus low age distribution and the resulting directionality of the self-fulfilling prophecy; that is, how initial relative age affects long-term educational performance.

Results and discussion

We conduct our analysis in stages, moving from the methodologies yielding the least to the most causal estimates. We begin with a descriptive relationship between age and performance, summarized by Figures 2.0 and 2.1 below:

Figure 2.0: Age vs. Performance, 2000

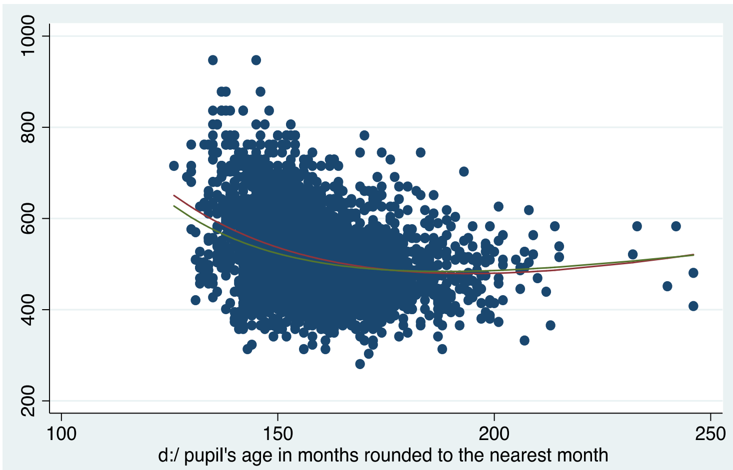
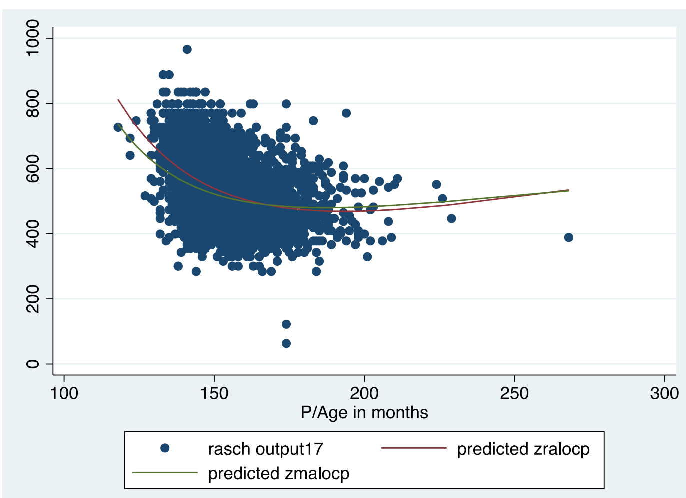


Figure 2.1: Age vs. Performance, 2006



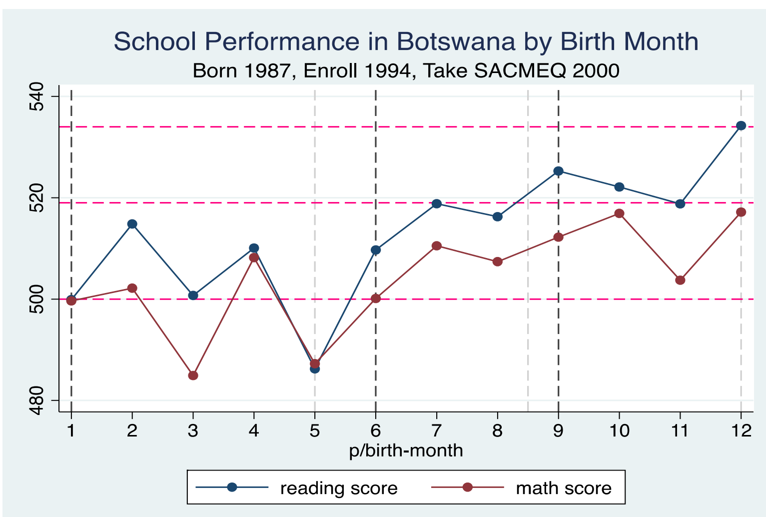
We observe clearly that the older you are, the worse you perform. Columns 1 and 7 in Table 1.0 and Table 1.1 in the Appendix quantify these effects. In 2000, being a year older corresponds to a decline of 22 points in reading and 16.68 points in math. This effect is even more pronounced in 2006. Being a year older correlates with a 35-point worse score in reading and a 23.76 reduction in math performance.

Next, we control for a host of variables. We include parent education, incidence of grade repetition, type of school, as well as numerous proxies for wealth, such as number of livestock, access to running water, and number of books at home. This result is summarized in Columns 4 and 10 in Table 1.0 and Table 1.1. We see that after including these controls, the effect of age on performance is diminished, yet remains highly negative and statistically significant at the 5% level. In 2000, a one-year increase in age resulted in a 5.76 and 3.72-point reduction in reading and math, respectively. In 2006, a one-year age increase yielded a 12.48 decline in reading scores, and a 6.96 reduction in math.

The reduced effects of age on performance, after the inclusion of control variables, indicates that wealth, school type and grade repetition were indeed driving a large part of the perceived effect of age on test scores. This is expected since older students tend to be poorer, are held back due to lower ability, and largely attend public schools, all of which generally lead to poorer performance. Yet, even after controlling, we still observe a negative and significant effect of age on performance. This suggests that age alone plays a major factor in educational outcomes.

Next we examine the effect of being born right before versus after the school cut-off date. Figure 3.0 summarizes the result:

Figure 3.0: Performance by Birth Month, SACMEQ 2000

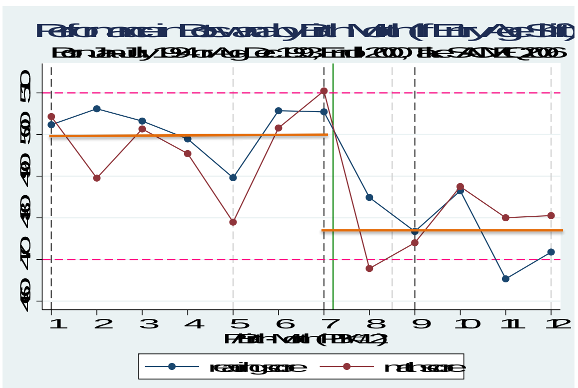


We see that if you are born in December (Month 12) you perform dramatically better than if you are born in January (Month 1). The vertical drop in performance equates to approximately a 40-point reduction in reading score and 20-point drop in math.

Since there is no systematic difference if you are born just a few days apart across gender, ability, wealth, geographic location or any other variable, this decline in performance can be uniquely attributed to the effect your birth date has on your relative age in school. Students born in December enroll on time, at age six and one month, by the January 3rd deadline. Students born in January miss the deadline to enroll and must wait a full year to enter school. By the time they enter school, they are six and eleven months old. While this initial age difference seems insignificant, 11 months is almost a 20% difference at age 6. The fact that performance twelve years later differs so dramatically across birth dates indicates that indeed relative age is a key determinant of educational attainment, and that small initial differences have long-lasting effects.

This trend holds, even after the school entry date shifts to 5 ½ years old, affecting the cohort of students taking SACMEQ 2006 but not SACMEQ 2000. This shift allowed students to enroll 6 months earlier than previously allowed. Thus, students born in July could enroll by the January 3rd enrollment deadline five years later, whereas students born in August were too young at the cutoff (five years and five months) and had to wait an extra year. If indeed birth date determines initial relative age in school, and in turn affects educational performance later in life, the performance discontinuity should shift from January to July. The graph below summarizes these results:

Figure 3.1: Performance by Birth Month, SACMEQ 2006



Indeed, we see a massive decline in performance, immediately before versus after July (month 7). The orange line of best fit highlights this trend. This trend parallels the same discontinuity observed in 2000 around the January cutoff, simply shifted due by the earlier start date.

In theory, we might be concerned that the discontinuity in the 2000 data around January was due to other factors that affect performance and also coincide with the month of January. For example a sharp increase in warm weather might increase the probability that children of the poor are born, as wealthier working folk spend more time outside and are less confined to the privacy of their home. Therefore, *weather* might be driving birth rates of the poor, who in turn tend to perform worse.

However, we observe a similar and discontinuous drop in performance in July, near-perfectly in sync with the shifting of the school entry date. This indicates that the interaction between start date and birth date is likely directly linked to performance, regardless of seasonal effects or chance.

Columns 6 and 12 in Table 1.0 and Table 1.1 quantify these results. In particular, we regress an unbiased dummy variable indicating if you were born before or after the cutoff, which increases relative age by 3-6 months, on test scores. This technique is known as instrumental variables estimation, since we use *assigned relative age* to instrument for observed age in an unbiased fashion. The results estimate a credibly causal impact of age on educational outcomes. In the 2000 SACMEQ, if a student was one month older, they did 3.13 points worse in reading, and 2.25 points worth in math. In 2006, older students did 5.25 points worth in reading, and 2.86 points worse in math.

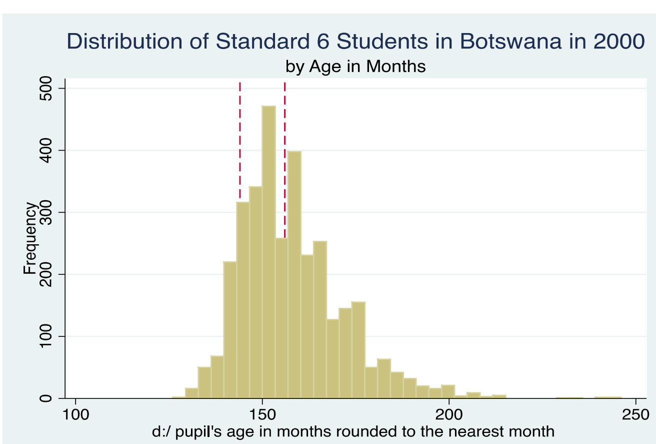
For ease of interpretation, we translate month effects into year effects. In 2000, being a year older meant you performed 38 and 27 points worse in reading and math respectively; in 2006 these effects nearly double, with older students performing 63 points worse in reading and 34 points worse in math.

We standardize these effects for comparison. This translates into a .64σ reduction in reading scores and .34σ reduction in math in 2006. To put this in perspective, the most effective educational interventions in the U.S., such as high-performing charter schools, boost performance by .1σ-.3σ annually, effectively closing the achievement gap between rich and poor in nearly four years. Thus, in Botswana, the educational gap between the relatively old and relatively young, independent of other factors including wealth, is as big or bigger than the entire educational gap between the rich and poor in the U.S.

Moreover, the data show that the effect of relative age on performance has become increasingly destructive over time. Between 2000 and 2006, the negative impact of relative age on test scores increased by 65.7% in reading, and 25.9% in math. This radical decline, in conjunction with overall test score drops, motivates a deeper understanding of why being relatively older in Botswana makes a student worse off.

We hypothesize that the self-fulfilling prophecy perpetuates initial educational endowments into long-run outcomes. In much of the Western world relatively older students are perceived as more physically and cognitively mature. Thus, older students receive special attention, realize this perceived ability, in turn receiving more attention, and so forth. The literature shows that students born after the school entry date, and are therefore relatively older, perform best.
However, in Botswana, relatively older students perform dramatically worse. We hypothesize that this is a result of unusual and massive age distribution, where an 11-year old and an 18-year old are often in the same classroom, and older students tend to come from poor, rural, and less educated backgrounds. Thus, older students are perceived as *less* able, and instead of receiving more attention are underinvested in, resulting in a self-fulfilling prophecy downwards.
Figure 4.0 and 4.1 below depict the distribution of age in months for Standard 6 students who took the 2000 SACMEQ.

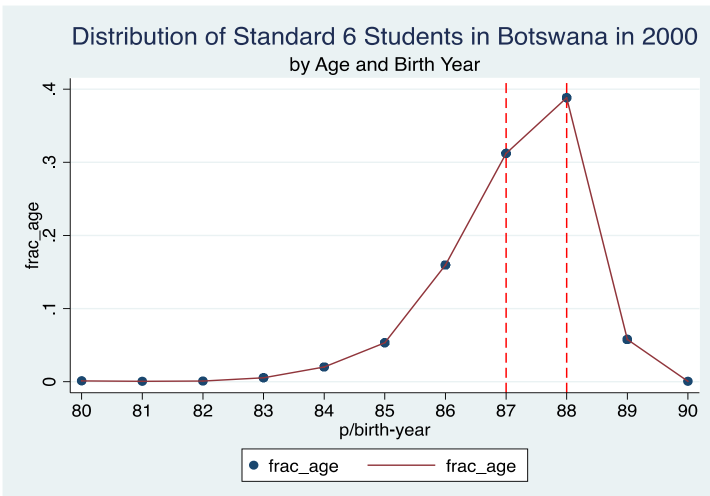
Figure 4.0: Number of Standard 6 Students who took the 2000 SACMEQ Per Age Group (in Months)



We see that indeed a large number of students fall out of the "expected" age, the region between the two dotted red lines. If a student enters school at age 6, as written into law, and progresses each year to the next grade level, by Standard 6 a student will be between 12-13 years old – the equivalent of 144 to 156 months. Yet, a large number of students fall out of this range. Some students are as young as 126 months, while others as old as 246 months, a full ten-year gap.

Figure 4.1 showcases the same trend in terms of the percentage of students born in the "right" years and who successfully progress to Standard 6 by the year 2000.

Figure 4.1: Percentage of Standard 6 Students who took the 2000 SACMEQ Born in the "Correct" Birth Year



We observe that only 70% of students are born in the "right" age (e.g. they were born in 1987 or 1988), indicating that almost a third of students either did not enroll on time, or failed to progress annually in school.

These trends persist six years later, even as Botswana became richer, more developed, and built better school infrastructure. Figure 5.0 and 5.1 below depict the age distribution in Standard 6 by age and birth date using data from 2006.

Figure 5.0: Number of Standard 6 Students who took the 2006 SACMEQ Per Age Group (in Months)

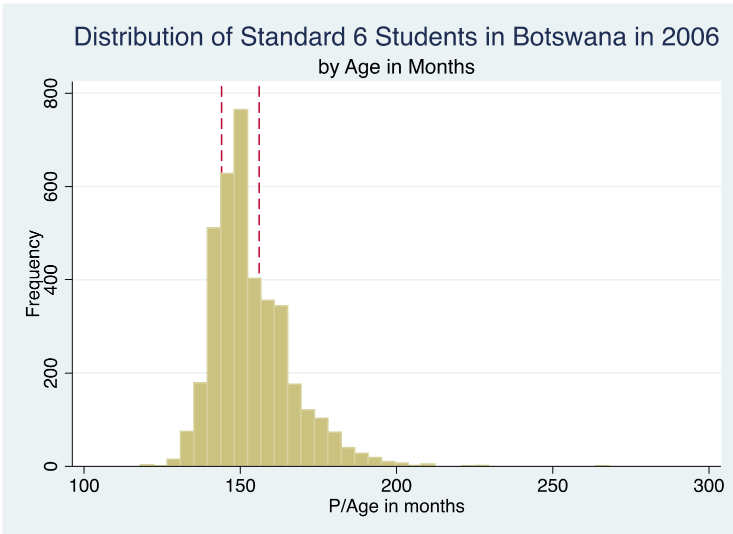
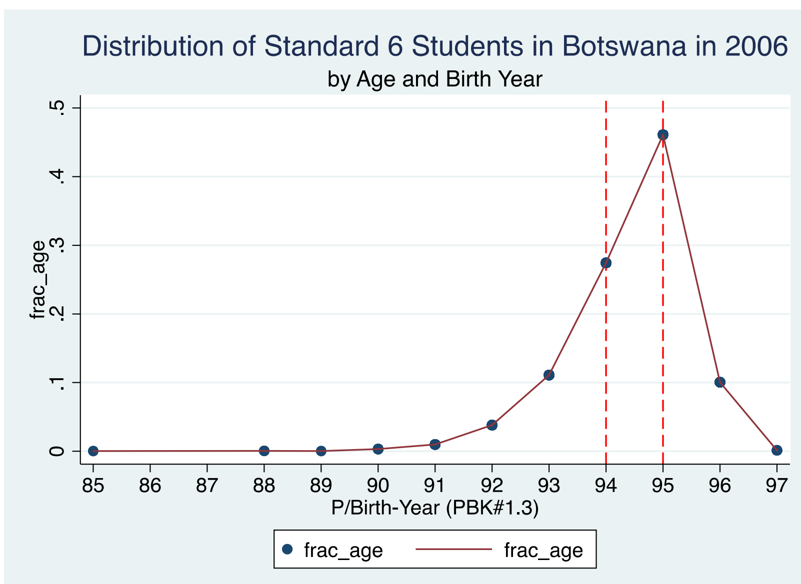


Figure 4.1: Percentage of Standard 6 Students who took the 2006 SACMEQ Born in the "Correct" Birth Year



We see that even in 2006, a large and similar proportion of students are the 'wrong" age in Standard 6. Almost 30% of students fall into the "wrong" age category. Moreover, the observe age range has widened further, ranging from 118 months to 268 months – a full 12-13 year age gap.

We stratify age distribution by geographical region and school type, to help explain the root cause of age distribution. The results of this analysis are shown in Figures 6.0-6.3 in the Appendix. Our analysis reveals that age distribution is no worse in rural areas than in towns or cities, but is markedly more pronounced in government schools relative to private schools.

The overall negative effects of massive age distribution on performance are obvious; imagine trying to teach a thirteen year old and twenty year-old at the same time. In addition, age distribution likely creates a negative perception of older students, who are kept on the farm longer prior to enrollment, repeat a grade, or are less able to begin with. This negative perception of older students extends to relative age – the difference between a student who is six and one month versus six and eleven months when they first enter school. Since differences in relative age are usually a result of arbitrary birth dates and school cutoffs, negative stigma towards older age results in underinvestment in older, high-potential students. This has large consequences for human capital endowments of a country, as many high potential students are unknowingly left behind.

We observe that as age distribution worsened between 2000 and 2006, the negative effect of relative age on school performance also became more pronounced. From 2000 to 2006, an increase of a two-year age gap between the youngest and oldest student in Standard 6 is accompanied by an increase in the negative impact of relative age on test scores of 65.7% in reading and 25.9% in math.

Conclusion

In this paper, we present results indicating that a child's birth date has a dramatic effect on their educational attainment later in life. This is likely due to the fact that students born right after the entry date must wait a full year to enroll, and therefore begin schooling at a relatively older age. Since older age is perceived as a sign of poverty and low-ability in Botswana, these students start at a disadvantage.

While this initial disadvantage might theoretically diminish over time, our results indicate that these disadvantages are in fact propagated. This is consistent with findings from Heckman et al. (2006) revealing that early skill development has significant effects on learning later in life.

This could have large consequences on Botswana's economy, as teachers invest in older, lower-achieving students instead of younger, higher-achieving students, mistakenly perceiving relative age difference for inherent ability or motivation.

Since birth date has little to do with wealth, motivation, or anything else, but results in dramatic changes in performance, it seems relative age alone is a major and causal driver of performance. Indeed, being just one year older, can translate into a $.64\sigma$ reduction in reading scores and $.34\sigma$ reduction in math in Botswana.

These findings have implications for skill acquisition across socioeconomic groups, since wealthier students often attend private schools, where age distribution is lower, and the negative stigma towards age almost non-existent. As a result, we observe far less performance difference by birth date for private schools. This indicates that poorer, government school children are particularly susceptible to this self-fulfilling prophecy downwards.

In conclusion, our results strongly indicate that in Botswana relatively older age causes worse performance later in life. This can have damaging and long-lasting effects on the future of a country, as older high-ability students are left behind. As such, teacher-training programs are advised to focus on the dynamics of age in the classroom. In addition, older students, instead of receiving less attention, should be given special support, to compensate for negative biases upon entry. Finally, it is imperative for policy to address the root cause of negative stigma towards age by enforcing entry age, and providing resources for all students to enroll and progress in school on time, to guard against the negative effects of massive age distribution.

Acknowledgement

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APPENDIX

Figure 6.0: Age Distribution by Birth Year and School Type, 2000

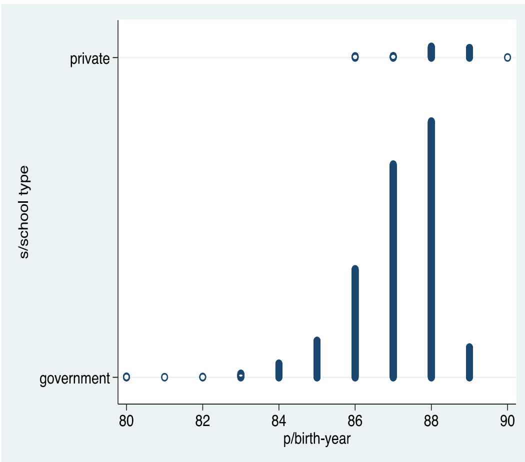

Figure 6.2: Age Distribution by Birth Year and School Type, 2006

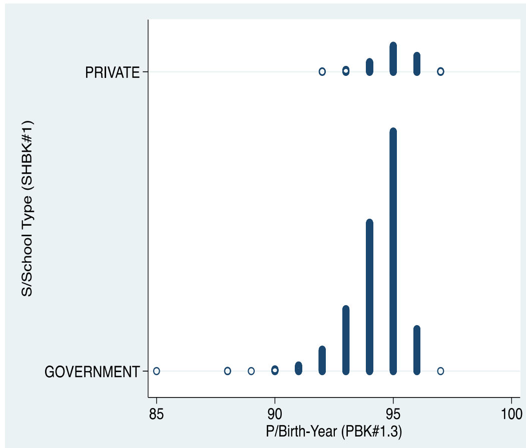

Figure 6.1: Age Distribution by Birth Year and Geographic Region, 2000

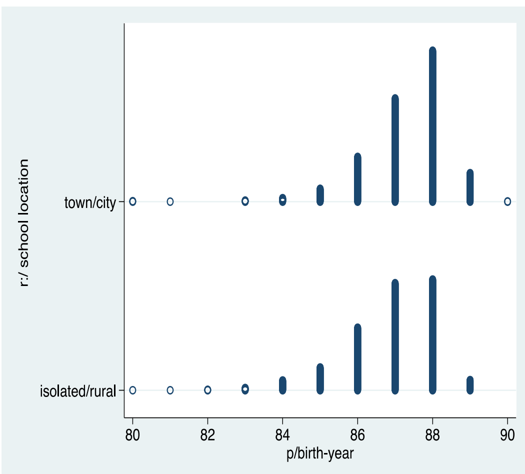

Figure 6.3: Age Distribution by Birth Year and Geographic Region, 2006

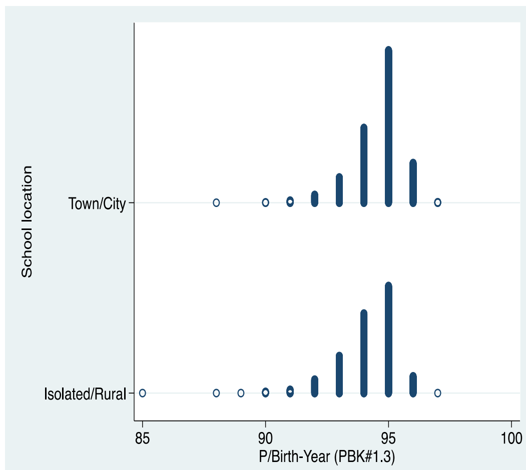

Table 1.0:

	The Effect of Age on Performance in Botswana, SACMEQ II (2000)											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Model Specification	OLS	Control	Controls	Controls	Sharp RDD	Fuzzy RDD	OLS	Control	Controls	Controls	Sharp RDD	Fuzzy RDD
	READING						MATH					
	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores
P/Age in months	-1.84***	-1.28***	-0.91***	-0.48***	-1.65	-3.13***	-1.39***	-0.83***	-0.52***	-0.31**	-0.99	-2.25***
	(0.11)	(0.11)	(0.11)	(0.14)	(1.36)	(0.86)	(0.10)	(0.11)	(0.10)	(0.13)	(1.29)	(0.81)
repeat		-41.10***	-42.60***	-39.13***				-40.51***	-41.83***	-38.83***		
		(3.39)	(3.21)	(3.96)				(3.18)	(3.03)	(3.79)		
school_type			148.85***	76.95***					130.70***	78.43***		
			(7.51)	(13.79)					(7.09)	(13.18)		
dummy_rd_policyshift_july					-8.80						-7.44	
					(9.57)						(9.06)	
Controls (Education, Wealth, Books, Water)	NO	NO	NO	YES	NO	NO	NO	NO	NO	YES	NO	NO
Discontinuity Dummy	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	YES	YES
Instrumental Discontunity Variable	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO	YES
Observations	3322	3322	3322	1935	1037	1037	3321	3321	3321	1935	1036	1036
r2	0.08	0.12	0.22	0.19	0.01	0.01	0.06	0.10	0.18	0.16	0.01	0.01

Standard errors in parentheses
="* p<.10 ** p<.05 *** p<.01"

Table 1.1:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	The Effect of Age on Performance in Botswana, SACMEQ III (2006)											
Model Specification	OLS	Control	Controls	Controls	Sharp RDD	Fuzzy RDD	OLS	Control	Controls	Controls	Sharp RDD	Fuzzy RDD
	READING						MATH					
	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores	Test Scores
P/Age in months	-2.92***	-2.22***	-1.73***	-1.04***	-1.99**	-5.25***	-1.98***	-1.56***	-1.16***	-0.58***	-2.55***	-2.86*
	(0.12)	(0.13)	(0.12)	(0.18)	(0.97)	(1.98)	(0.10)	(0.11)	(0.10)	(0.15)	(0.84)	(1.70)
repeat		-44.07***	-46.41***	-35.88***				-26.57***	-28.48***	-23.32***		
		(3.46)	(3.25)	(4.86)				(2.90)	(2.74)	(4.08)		
school_type			105.82***	64.09***					86.30***	41.16***		
			(4.73)	(13.55)					(3.98)	(11.39)		
dummy_rd_policyshift_july					-9.86						-0.95	
					(6.64)						(5.76)	
Controls (Education, Wealth, Books, Water)	NO	NO	NO	YES	NO	NO	NO	NO	NO	YES	NO	NO
Discontinuity Dummy	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	YES	YES
Instrumental Discontunity Variable	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO	YES
Observations	3868	3868	3868	1255	782	782	3865	3865	3865	1252	781	781
r2	0.14	0.17	0.27	0.19	0.01	0.00	0.10	0.12	0.21	0.12	0.02	0.02

Standard errors in parentheses
="* p<.10 ** p<.05 *** p<.01"